# Service Manual

## HP M2475B CodeMaster 100 Portable Defibrillator/Monitor with Integrated 12-Lead ECG Option (C90)

Includes additional service data for:

HP M2480B Battery Support System
HP M2478A DC Power Module
HP M2479A AC Power Module
Shock Advisory Option (C80)

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# Notice


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As with electronic equipment, **Radio Frequency** (RF) interference between the defibrillator and any existing RF transmitting or receiving equipment at the installation site, including electrosurgical equipment, should evaluated carefully and any limitations noted before the equipment is placed in service

Monitoring during quiescent periods of electrosurgery is possible but electromagnetic interference generated by electrosurgical tools during operation is sufficient to mask cardiac signals. A momentary recovery period is required for the monitor to return to normal operation and will be longer if the diagnostic monitoring mode is used. Pads or electrodes should be placed as far from the surgical area as reasonable while still performing normal function to minimize the possibility of burns. Radio frequency generation from electrosurgical equipment and close proximity transmitters may seriously degrade performance of the CodeMaster 100 portable defibrillator/monitor.

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## CAUTION
The manufacturer, importer and seller are responsible for the effects on safety, reliability and performance only if: assembly operations, extensions, re-adjustments, modifications or repair are carried out by persons authorized by them, and the electrical installation of the relevant room complies with all local regulations and the equipment is used in accordance with the instructions for use. Use of accessories other than those recommended by Hewlett-Packard may compromise product performance.

THIS PRODUCT IS NOT INTENDED FOR HOME USE.

## Responsibility of Manufacturer
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assembly operations, extensions, re-adjustments, modifications or repairs are done by persons authorized by Hewlett-Packard, and

the electrical installation of the relevant room or vehicle complies with the IEC or national requirements, and

the instrument is used according to the instructions for use presented in this manual.

# Safety Summary

## Safety Symbols Marked on the Defibrillator

The following symbols are used on the defibrillator.


On (Do not confuse with 1 Joule)

Off (Standby)

Shock hazard

Caution - See operating instructions

Meets IEC type BF leakage current requirements and is defibrillator protected.

Meets IEC type CF leakage current requirements and is defibrillator protected.

Please see Chapter 3, **Performance Verification and Maintenance**, for safety requirements that apply to the defibrillator.

## Symbols Marked on the Battery Support System

The following symbols are used on the battery support system.

Do not use in the presence of flammable anesthetics or in oxygen rich environments.

AC power on.

Ground

Equipotential (rear of unit, adjacent to AC input)

Protective earth (ground)

Start battery capacity test.

Battery charging.

Battery capacity test.

Additional information.

## Conventions Used in This Manual

**WARNING**

**Warning statements describe conditions or actions that can result in personal injury or loss of life.**

**CAUTION**

Caution statements describe conditions or actions that can result in damage to the equipment or software.

**NOTE**

Notes contain additional information on defibrillator usage.

TEXT represents the messages that appear on the display.

key represents keys on the front panel.

LIGHT represents lighted indicators on the key panel.

# Preface

This manual contains service information for the HP M2475B CodeMaster 100 Portable Defibrillator/Monitor with Integrated 12-Lead, the HP M2480B Battery Support System, the HP 2478A DC Power Module and the HP M2479A AC Power Module.

This manual is organized as follows:

**Chapter 1, Introduction**. Contains a general description of the defibrillator, battery support system, lists of technical specifications, and lists of options and accessories.

**Chapter 2, Configuration**. Explains how to configure the defibrillator for specific customer requirements.

**Chapter 3, Performance Verification and Maintenance**. Explains how to check the defibrillator’s performance using built-in tests, and lists maintenance procedures and safety requirements that apply to the defibrillator.

**Chapter 4, Troubleshooting**. Contains procedures and error codes to aid the service person in localizing faults to a replaceable subassembly.

**Chapter 5, Removal and Replacement**. Contains procedures for removing and replacing each of the defibrillator's major subassemblies.

**Chapter 6, Theory of Operation.** Provides an overview of how the defibrillator works and describes the operation of the major subassemblies.

**Chapter 7, Parts Lists**. Lists part numbers for the defibrillator's replaceable parts, and provides assembly drawings.

**Appendix A, Connector Pin Assignments**. Identifies and defines the signals assigned to the subassembly interconnections.

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# Introduction

## General Information

This chapter provides a general description and technical specifications for the HP M2475B CodeMaster 100 Portable Defibrillator/Monitor with Integrated 12-Lead ECG.

General descriptions and specifications for its companion defibrillator/monitor battery support system and external DC and AC power modules are also included:

- HP M2480B Battery Support System
- HP M2478A DC Power Module
- HP M2479A AC Power Module

### Repair Philosophy

**M2475B CodeMaster 100 Portable Defibrillator/Monitor with Integrated 12-Lead ECG:** Repair philosophy for the M2475B Defibrillator/Monitor is modular assembly replacement; individual component level maintenance is not supported. Replaceable modular assemblies available for the M2475B are identified in Chapter 7, *Parts Lists*.

**Battery Support System and DC/AC Power Modules**: Repair philosophy for the M2480B Battery Support System, the external M2478A DC Power Module and the M2479A AC Power Module is instrument replacement; i.e., the customer returns the defective unit to Hewlett-Packard Co. (The only replaceable assemblies for these instruments are fuse and cable assemblies as identified in Chapter 7.)

**WARNING**

**Dangerous voltages are exposed when performing service procedures. Be certain not to touch the circuitry, wiring, or components while performing this procedure. Dangerous voltages capable of causing injury or death are present at the paddles during normal operation. This defibrillator is to be used and serviced only by qualified personnel.**

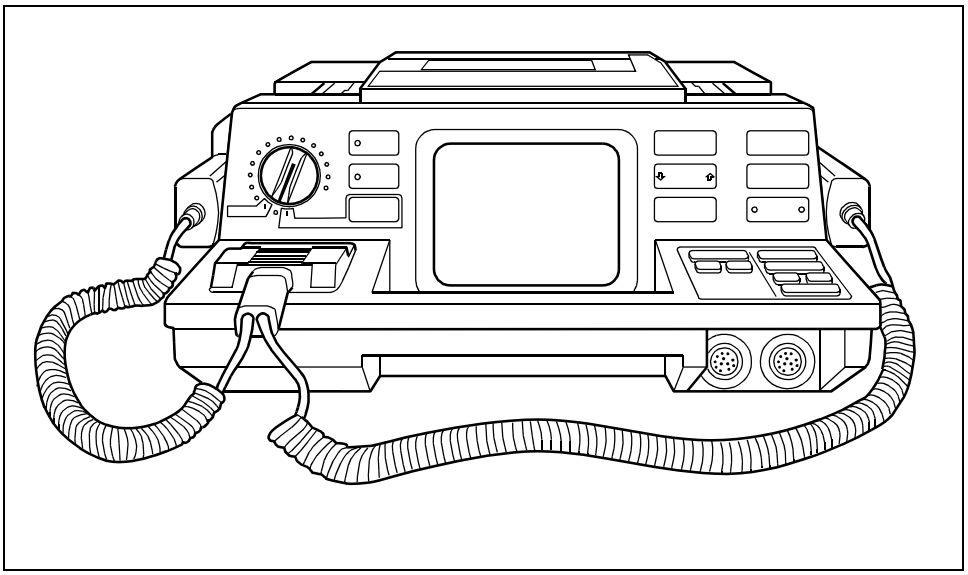
**CAUTION**

Operation of this device in the vicinity of high-powered transmitters or electrosurgical instruments may result in interference of the ECG display.

**NOTE**

Safe and effective use of medical instrumentation requires periodic inspection and preventive maintenance. Perform the preventive maintenance procedures described in Chapter 3 of this manual at the required intervals to ensure satisfactory instrument performance.

**Figure 1-1**



**HP CodeMaster 100 Portable Defibrillator/Monitor with integrated 12-Lead ECG Option**

# HP CodeMaster 100 Portable Defibrillator/Monitor with Integrated 12-Lead

The HP Codemaster 100 (see Figure 1-1) is a portable defibrillator/monitor powered by a quick-change battery. It combines a 360-joule defibrillator, ECG monitor, and annotating strip chart recorder in a compact, light-weight package. Instrument features include crisis-oriented controls, fast charge, a quick-change battery, a real-time clock, interchangeable paddles, and automatic documentation of events. The monitor includes a 5-inch screen which displays the ECG, selected ECG source, heart rate, and messages and alerts. A microprocessor-based system rejects noise and artifact, and automatically stabilizes and restores baseline.

The instrument has adjustable heart rate alarms, paddle contact indicator (PCI), recorder event marker, complete recorder annotation, event summary, 3- and 5-wire patient cable ECG capability, transcutaneous external pacing and pulse oximetry. An optional 12-pin ECG input connector is compatible with the ECG patient cable. The instrument can interface via an analog-only high-level ECG Out signal.

Designed for long-term reliability, the instrument's modular design makes extensive use of VLSI and gate-array technology. The modular approach means less downtime for the user, due to the quick field repair times inherent in the subassembly replacement philosophy of repair. The built-in menu-driven tests efficiently aid in identifying faulty operation, further speeding the repair process.

The instrument incorporates HP-PAC packaging technology. HP-PAC is a recyclable Expanded Polypropylene (EPP)-based foam packaging material that meets appropriate safety requirements.

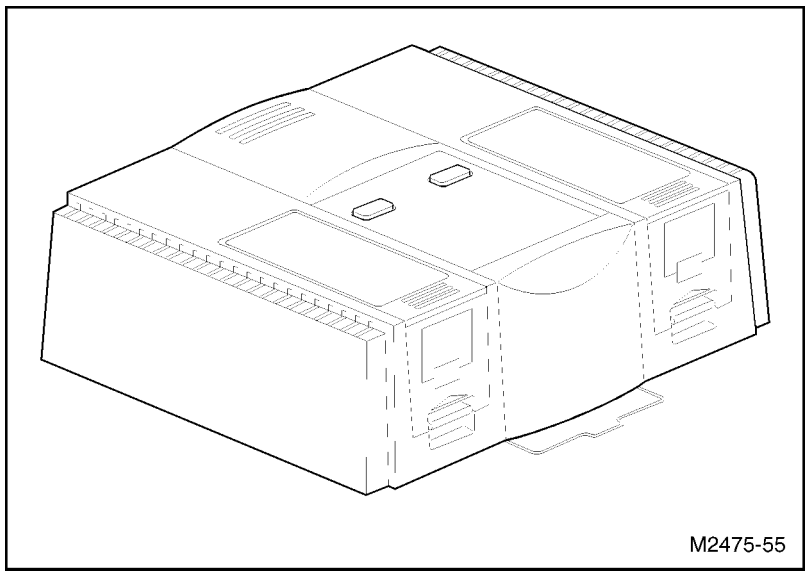
HP-PAC replaces current packaging technology with a light weight alternative. HP-PAC reduces the number of internal fasteners and provides unique indentations in the molding for parts. In addition, this technology provides improved protection from shock and vibration and facilitates better cooling. This greatly improves equipment performance and reliability.

The optional battery support system, DC power module, and AC power module available for use with the HP CodeMaster 100 are described in the following paragraphs.

## HP M2480B Battery Support System

The HP M2480B Battery Support System can be used to charge and test batteries used in the HP CodeMaster 100 (the battery support system can charge and perform a capacity test on both channels simultaneously). The battery support system provides a capacity test indicator that flashes to indicate when a capacity test should be performed on the battery. The battery capacity test checks battery capacity, and reconditions and charges the battery.

**Figure 1-2**




**HP M2480B Battery Support System**

## M2478A DC Power Module

The HP M2478A is a 12-Volt DC power source for the HP M2475B CodeMaster 100 Portable Defibrillator/Monitor with Integrated 12-Lead. This module is designed specifically for emergency vehicles with 12 Volt DC electrical systems. With this module, your vehicle's 12 Volt system can power the HP CodeMaster 100, saving the defibrillator/monitor battery for remote use. Additionally, the HP CodeMaster 100 battery is recharged when it is attached to the Portable Defibrillator/Monitor.

Detailed operational procedures for the HP DC Power Module are provided in the *HP M2478A External DC Power Module User's Guide*, part number M2475-91950.

## HP M2479A AC Power Module

The HP M2479A interfaces between an AC power source and the HP CodeMaster 100, supplying an operating source voltage as well as a continuous battery charger for the HP CodeMaster 100. Continuous battery charging ensures that the HP CodeMaster 100 is ready for portable operation should an emergency situation occur.

Detailed operational procedures for the HP AC Power Module are provided in the *HP M2479A AC Power Module User's Guide*, part number M2479-91901.

## Inquiries

For questions or comments regarding these instruments, contact the nearest HP Sales/Service Office or one of HP's Service Dispatch Centers. Always identify the instrument by model number and serial number in all correspondence. Hewlett-Packard sales and service offices are listed at the end of this manual. Toll-free numbers for Service Dispatch Centers are listed under *Calling for Assistance* in Chapter 7 of this manual.

# Technical Specifications

Tables 1-1 through 1-9 list technical specifications for the HP CodeMaster 100 and its associated external battery support system, DC power module and AC power module.

- Table 1-1, Physical Specifications (all units - M2475B, M2480B, M2478A, M2479A)
- Table 1-2, M2475B CodeMaster 100 Environmental Specifications
- Table 1-3, M2475B CodeMaster 100 Electrical Specifications
- Table 1-4, M2475B CodeMaster 100 Battery Specifications
- Table 1-5, M2475B CodeMaster 100 External Pacer Specifications
- Table 1-6, M2475B CodeMaster 100 $SpO_2$ Monitor Specifications
- Table 1-7, M2480B Battery Support System Specifications
- Table 1-8, M2478A DC Power Module Environmental Specifications
- Table 1-9, M2479A AC Power Module Environmental Specifications

**Table 1-1** **Physical Specifications (All Units - M2475B, M2480B, M2478A, M2479A)**

| Parameter | Specification |
|---|---|
| ***Dimensions (h × w × d):*** | |
| HP M2475B Defibrillator | 7.25" H × 13.75" W × 15.13" D (18.5 cm H × 34.9 cm W × 38.4 cm D) |
| HP M2477B 2.5 Amp-hour Battery | 3.35" H × 2.96" W × 7.25" D (8.5 cm H × 7.5 cm W × 18.4 cm D) |
| HP M2477B 4.0 Amp-hour Battery | 3.35" H × 2.96" W × 7.25" D (8.5 cm H × 7.5 cm W × 18.4 cm D) |
| HP M2480B Battery Support System | 5.1" H × 14.6″ W × 12.5" D (13.0 cm H × 37.1 cm W × 31.8 cm D) |
| HP M2478A DC Power Module | 1.75" H × 5.5" W × 3.25" D (4.44 cm H × 14 cm W × 8.25 cm D) |
| HP M2479A AC Power Module | 3.625" H × 8.375" W × 9.0" D (9.21 cm H × 21.3 cm W × 22.9 cm D) |
| ***Weight:*** | |
| HP M2475B Defibrillator | 23.5 lb 10.65 kg) Includes external paddles, 2.5 Ah battery, and recorder paper. |
| HP M2476B 2.5 Amp-hour Battery | 2.7 lb (1.22 kg). |
| HP M2477B 4.0 Amp-hour Battery | 4.3 lb (1.95 kg). |
| HP M2480B Battery Support System | 14.5 lb (6.58 kg) not including battery or power cord. |
| HP M2478A DC Power Module | 1.1 lb (0.5 kg). |
| HP M2479A AC Power Module | 4.0 lb (1.8 kg). |

**Table 1-1** **Physical Specifications (All Units - M2475B, M2480B, M2478A, M2479A) (Continued)**

| Parameter | Specification |
|---|---|
| ***Chemical resistance:*** | |
| Cleaners | All units withstand the following: isopropyl alcohol (except leadwires and patient cable), mild soap and water, chlorine bleach and water (30 ml/l of water). |

**CAUTION**

The main battery will be damaged if stored for extended periods at a temperature greater than 35° C.

**Table 1-2** **M2475B CodeMaster 100 Environmental Specifications**

| Parameter | Specification |
|---|---|
| ***Temperature:*** | |
| operating | 0° to 55° C (32° to 131° F). |
| storage | –20° to 70° C (–4° to 158° F) [1]. |
| ***Humidity:*** | |
| operating | 15 to 95% RH, for 24 hours at 40° C (104° F) [2]. |
| storage | 90% RH for 24 hours at 65° C (149° F).[1] |
| ***Pressure (altitude)*** | |
| operating | To 15,000 ft. (4600 m). |
| storage | To 15,000 ft. (4600 m). |

[1] Storage for extended periods above 35 ° C damages the battery pack. Recorder paper darkens at 55 ° C and above.

[2] The recorder is limited to operation below 80% RH since the recorder paper is not specified for use above 80% RH.

**Table 1-3 M2475B CodeMaster 100 Electrical Specifications**

| Parameter | Specification |
|---|---|
| ***Defibrillator section:*** | |
| Output energy (delivered): | 2, 3, 5J (±1J). |
| | 7, 10J (±2J). |
| | 20, 30J (±4J). |
| | 50, 70, 100, 150, 200, 300, and 360J (±15%). |
| Waveform | Damped sinusoidal (Low). |

**Table 1-3 M2475B CodeMaster 100 Electrical Specifications (Continued)**

| Parameter | Specification |
|---|---|
| Charge control | Push-button on apex paddle and on front panel. |
| Charge time (Battery operation) | Less than 5 seconds to 360 joules. |
| Armed indicators | Charge done tone, charge done light on apex paddle and on defibrillator font panel, and available energy indicated on display. |
| Paddle contact indicator (PCI) | 3-color LED bar graph array on sternum paddle indicates quality of defibrillator paddle contact before discharge. |
| Paddles | Standard paddles are anterior/anterior, water resistant, adult and pediatric with paddle contact indicator (PCI). Adult electrodes (83 cm sq) slide off to expose pediatric electrodes (21 cm sq). Paddle cord is 10 ft (3m). Full range of internal paddles is available. |
| Synchronizer | SYNC message appears on monitor and is annotated periodically on recorder while in synchronous mode. An audible beep sounds with each detected R- wave, while a marker on the monitor and sync designator on the recorder strip indicate the discharge point. |
| ***Monitor section:*** | |
| Inputs | ECG may be viewed through paddles or patient cable. Lead I, II, III, or PADDLES selectable. Additional 5-Lead ECG (avR, avF, avL, V Leads) and PADS are available. Monitor and recorder indicate selected ECG source. |
| Lead fault | LEADS OFF message and dashed baseline appear on monitor if a lead becomes disconnected. |
| Common mode rejection | Leads: ≥90 dB and Paddles: ≥90 dB measured as per AAMI standards for cardiac monitors (EC13). |
| Pace pulse rejection | The pace pulse rejection algorithm of this product meets the requirements of Section 3.1.4.1 (Pacemaker Pulse Rejection Without Over/Undershoot) of AAMI EC13 - 1992 (Cardiac Monitors, Heart Rate Meters and Alarms). This product will not reject pace pulses as described in Section 3.1.4.2 (Pacemaker Pulse Rejection With Over/Undershoot) of the same document. |
| Display size and type | 5 inch diagonal (12.7 cm) CRT for 4 seconds of ECG data on screen; non-fade, fixed trace. Scrolling trace is selectable. |
| Sweep speed | 25 mm/sec nominal.<br>28.5 mm/sec nominal (scrolling trace). |
| Frequency response | 0.5 to 40 Hz. |
| Heart rate display | Digital readout on monitor from 15 to 300 BPM. |
| Heart rate alarms | Three pairs of configurable high and low heart rate alarm limits from 20 to 280 BPM. |
| ECG output | 1 V/mV. |
| Patient cable length | 10 ft (3m). |
| Indicators | LOW BATTERY message appears on monitor when limited battery capacity. |
| ***Thermal Array Recorder section:*** | |
| Event summary | Stores and prints 3 seconds of pre-critical event data, and 8 seconds of post-critical event data for up to 28 events. Data is retained after unit is turned off. |
| Annotates | Time, date, HR, pacing current and rate and $SpO_2$ reading, ECG mode, event marker, defibrillator mode, selected energy, actual delivered energy, peak current, and patient impedance. |

**Table 1-3 M2475B CodeMaster 100 Electrical Specifications (Continued)**

| Parameter | Specification |
|---|---|
| Speed | 25 mm/sec. |
| Paper size | 50 mm by 30 m (100 ft). |
| Recorder mode | May be configured to automatically document events and ECG during defibrillation episodes. The recorder can be configured to run in either real time or with a 6 second delay. |
| Frequency response | 0.5 to 40 Hz (for leads or multi-function pads). Additionally, 0.05–150 Hz selectable (for leads only). |

**Table 1-4 M2475B CodeMaster Battery Specifications**

| Parameter | Specification |
|---|---|
| ***HP M2476B 2.5 Ah Battery:*** | |
| Type | Rechargeable nickel-cadmium battery, 2.5 Ah, 12 V nominal. |
| Charge time | Approximately 2 hours to full capacity when battery is fully discharged. |
| Capacity | 2500 mAh; approximately 2.5 hours of monitoring, or 50 full-energy discharges, or 1.75 hours of combined ECG monitoring and pacing. |
| Indicators | Battery capacity gauge with five lights indicating remaining capacity. Each light represents approximately 20% of battery capacity. |
| ***HP M2477B 4.0 Ah Battery:*** | |
| Type | Rechargeable nickel-cadmium battery, 4.0 Ah, 12 V nominal. |
| Charge time | Approximately 3 hours to full capacity when battery is fully discharged. |
| Capacity | 4000 mAh; approximately four hours of monitoring, or 75 full-energy discharges, or three hours of combined ECG monitoring and pacing. |
| Indicators | Battery capacity gauge with five lights indicating remaining capacity. Each light represents approximately 20% of battery capacity. |

**Table 1-5 M2475B External Pacer Specifications**

| Parameter | Specification |
|---|---|
| Current pulse amplitude | 10 mA to 50 mA; +/- 5 mA<br>50 mA to 200 mA; +/- 10% |
| Pulse width | 20 msec. +0/-5 msec |
| Rate | 40 ppm to 180 ppm. +/- 1.5% |
| Modes | Demand or fixed rate. |
| Refractory period | 40 to ≤80 ppm: 340 msec ±10%.<br>> 80 to 180 ppm: 240 msec ±10%. |

**Table 1-6** **M2475B CodeMaster 100 $SpO_2$ Monitor Specifications**

| Parameter | Specification |
|---|---|
| $SpO_2$ measurement | Range: 0 to 100%.<br>Accuracy with HP 1190A transducer: 1 standard deviation:<br>65% to 100%:±/2.5%.<br>Accuracy with Nellcor N-25, I-20, D-20, D-25, Oxiband A/N, Oxiband P/I sensors.<br>1 standard deviation:<br>80% to 100%: ±3%. |
| Pulse rate measurement | Range: 30 to 300 bpm.<br>Accuracy: ±2%.<br>Resolution: 1bpm. |
| Averaging | $SpO_2$ and pulse rate: averaged over eight beats. |
| $SpO_2$ alarm limits | Three preset limits: 100/90, 100/85, and 100/80. Default is alarm off. |
| Time to alarm | Alarm within 10 seconds of $SpO_2$ value dropping below alarm setting. |
| Time to valid numeric | Valid 15 seconds after power on. |
| Recovery after defibrillation | Valid numeric 15 seconds after a discharge. |
| INOP alerts | Warning messages for:<br>$SpO_2$ cable off.<br>noisy signal.<br>low signal.<br>light interference. |
| Pulse amplitude indicator | Indicates pulsatile activity. |

**Table 1-7** **M2480B Battery Support System Specifications**

| Parameter | Specification |
|---|---|
| Charging capacity | Two batteries. |
| Charge time | Typically two to three hours. |
| Capacity test time | Approximately 24 hours. |
| Recommended battery charging temperature | 10 °C to 30 °C (50 °F to 86 °F). |
| Environmental operating conditions | 0 °C to 55 °C (32 °F to 131 °F).<br>15% to 95% relative humidity for 24 hours at 40 °C (104 °F).<br>-1000 ft to 15000 ft (-300 m to 4600 m) altitude. |
| Storage conditions | -20 °C to 70 °C (-4 °F to 158 °F).<br>90% relative humidity for 24 hours at 65 °C (149 °F).<br>-1000 ft to 15000 ft (-300 m to 4600 m) altitude. |

**Table 1-8 M2478A DC Power Module Environmental Specifications**

| Parameter | Specification |
|---|---|
| ***Temperature:*** | |
| operating | 0° to 55° C (32° to 131° F). |
| storage | –20° to 70° C (–4° to 158° F). |
| ***Humidity:*** | |
| operating | 15 to 95% RH, for 24 hours at 40° C (104° F) |
| storage | 90% RH for 24 hours at 65° C (149° F). |
| ***Pressure (altitude):*** | |
| operating | To 15,000 ft. (4600 m). |
| storage | To 15,000 ft. (4600 m). |

**Table 1-9 M2479A AC Power Module Environmental Specifications**

| Parameter | Specification |
|---|---|
| ***Temperature:*** | |
| operating | 0° to 55° C (32° to 131° F). |
| storage | –20° to 70° C (–4° to 158° F). |
| ***Humidity:*** | |
| operating | 5 to 90% RH, for 24 hours at 40° C (104° F) |
| storage | 10 to 100% RH, including condensation |
| ***Pressure (altitude):*** | |
| operating | To 15,000 ft. (4600 m). |
| storage | To 15,000 ft. (4600 m). |

**Table 1-10 CodeMaster 100 with 12-Lead ECG Specifications**

| Parameter | Specification |
|---|---|
| ***Frequency Response*** | selectable from the following ranges:<br>0.05-150, 0.15-150, 0.5-150 Hz<br>0.05-100, 0.15-100, 0.5-100 Hz<br>0.05-40, 0.15-40, 0.5-40 Hz |
| ***Filters*** | ***Noise Filter:*** On/Off capability. Power line filter always enabled. Configurable baseline wander, noise, and artifact filters. |

**Table 1-10 CodeMaster 100 with 12-Lead ECG Specifications (Continued)**

| Parameter | Specification |
|---|---|
| ***Storage*** | ***Capacity:*** 30 ECGs<br>***Type:*** 2 MB of non-removable flash memory |
| ***Modem Command Interfaces*** | Data: Hayes standard AT command set<br>Fax: EIA/TIA - 578 Service Class 1 |
| | ***Recommended Modem Protocols:***<br>Modulation Protocol: V.34<br>Error Correction Protocol: V.42<br>Compression Protocol: V.42 bis<br>Fax Modulation Protocol: V.17, V.29, V.27ter, V.21 channel 2 |

# Options and Accessories

## HP M2475B CodeMaster 100 Options/Accessories

Tables 1-10 through 1-17 list available options and accessories for the HP M2475B.

**Table 1-11** **M2475B CodeMaster 100 Country Options**

| Option | Country | Labels | Users Manuals | In-Service Training Video | Patient Cable |
|---|---|---|---|---|---|
| ABA | US | English | English | English NTSC | AAMI |
| ABB | Europe | English | English | English PAL | IEC |
| ABC | Canada | French | French | French NTSC | AAMI |
| ABD | Germany | German | German | German PAL | IEC |
| ABE | Spain | Spanish | Spanish | Spanish PAL | IEC |
| ABF | France | French | French | French PAL | IEC |
| ABG | Australia | English | English | English PAL | AAMI |
| ABH | Netherlands | Dutch | Dutch | Dutch PAL | IEC |
| ABK | Intercon English | English | English | English PAL | AAMI |
| ABM | Latin America | Spanish | Spanish | Spanish NTSC | AAMI |
| ABN | Norway | Norwegian | Norwegian | | IEC |
| ABP | Switzerland | German | German | German PAL | IEC |
| ABQ | Switzerland | French | French | French PAL | IEC |
| ABS | Sweden | Swedish | Swedish | | IEC |
| ABU | United Kingdom | English | English | English PAL | IEC |
| ABZ | Italy | Italian | Italian | Italian PAL | IEC |
| ACD | Switzerland | English | English | English PAL | IEC |
| ACQ | South Africa | English | English | English PAL | IEC |
| AKL | Thailand | English | English | English PAL | IEC |
| AKM | China | English | English | English PAL | IEC |
| AKV | South America | Spanish | Spanish | Spanish PAL | AAMI |

**Table 1-12 M2475B CodeMaster 100 Documentation Part Numbers**

| Language | User Guide Part Number | Quick Reference Part Number | $SpO_2$ Concept Guide | $SpO_2$ Sensor Guide | Shock Advisory User Guide | Shock Advisory Concept Guide | Carry Bag Instructions | In-Service Training Video |
|---|---|---|---|---|---|---|---|---|
| English | M2475-91980 | M2475-97800 | M1722-93950 | M1722-93970 | M1722-94960 | M1722-94940 | M2475-94000 | M2475-89300 NTSC<br>M2475-89350 PAL |
| French | M2475-91981 | M2475-97801 | M1722-93951 | M1722-93971 | M1722-94961 | M1722-94941 | M2475-94001 | M2475-89301 NTSC<br>M2475-89351 PAL |
| German | M2475-91982 | M2475-97802 | M1722-93952 | M1722-93972 | M1722-94962 | M1722-94942 | M2475-94002 | M2475-89352 PAL |
| Dutch | M2475-91983 | M2475-97803 | M1722-93953 | M1722-93973 | M1722-94963 | M1722-94943 | M2475-94003 | M2475-89353 PAL |
| Spanish | M2475-91984 | M2475-97804 | M1722-93954 | M1722-93974 | M1722-94964 | M1722-94944 | M2475-94004 | M2475-89304 NTSC<br>M2475-89354 PAL |
| Italian | M2475-91985 | M2475-97805 | M1722-93955 | M1722-93975 | M1722-94965 | M1722-94945 | M2475-94005 | M2475-89355 PAL |
| Swedish | M2475-91986 | M2475-97806 | M1722-93956 | M1722-93976 | M1722-94966 | M1722-94946 | M2475-94009 | |
| Norwegian | M2475-91989 | M2475-97809 | M1722-93959 | M1722-93979 | M1722-94969 | M1722-94949 | M2475-94008 | |
| Finnish | M2475-91988 | M2475-97808 | M2475-93958 | M1722-93978 | M1722-94968 | M1722-94948 | M2475-94006 | |

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**Table 1-13 M2475B CodeMaster 100 ECG Cable/Connector Options**

| Option | Description |
|---|---|
| C30 | Substitute 6-pin AAMI standard ECG connector and cable, AAMI colors |
| C31 | Substitute 6-pin 5-wire AAMI standard ECG connector, AAMI colors |
| C32 | Substitute 12-pin AAMI standard ECG connector and cable with HP Component Monitoring system, 12-pin connector and 3-wire AAMI patient cable set |
| C33 | Substitute 12-pin 5-wire AAMI standard ECG connector and cable with HP Component Monitoring system, 12-pin connector and 5-wire AAMI patient cable set |
| C36 | Substitute 5-wire AAMI standard Patient Cable |

**Table 1-14 M2475B CodeMaster 100 Hardware Options**

| Option | Description |
|---|---|
| C51 | Defibrillator Carrying Case (M2474A), includes accessory pouch (M2473A) |
| C52 | Accessory Pouch (M2473A) water-resistant softside case, holds electrodes, cables, $SpO_2$ sensor, and other accessories (M3710A) |
| C53 | Defibrillator carrying case with accessory pouch (black), M3711A |
| C54 | Accessory pouch (black), M3712A |

**Table 1-15 M2475B CodeMaster 100 $SpO_2$ Options**

| Option | Description |
|---|---|
| C73 | Additional adult reusable $SpO_2$ sensor, M1190A |
| C74 | Adaptor for Nellcor $SpO_2$ sensors, M1900B |
| C80 | Shock Advisory |

**Table 1-16 M2475B CodeMaster 100 Sync Cable Options**

| Option | Description |
|---|---|
| J01 | 8-pin Sync Cable (14482A) provides ECG signal from monitoring source. Cable has 1000:1 divider. Use with 8-pin ECG defibrillator connector. |
| J03 | 12-pin HP CMS Sync Cable (M1783A) provides ECG signal from monitoring source. Cable has 1000:1 divider. Use with 12-pin ECG defibrillator connector. |

**Table 1-17** **M2475B CodeMaster 100 NiCad Battery Options**

| Option | Description |
|---|---|
| C76 | Additional 2.5 Ah NiCad battery. |
| C77 | 4.0 Ah NiCad battery. |

**Table 1-18** **M2475B CodeMaster 100 Documentation Options**

| Option | Description |
|---|---|
| 0B3 | Service Manual (English only) (M2475-90905) |

### M2475B CodeMaster 100 Standard Accessories Supplied

- HP CodeMaster 100 Portable Defibrillator/Monitor User's Guide
- HP CodeMaster 100 Portable Defibrillator/Monitor Quick Reference Guide
- ECG Patient Cable (language/country specific)—HP M3415A/M3416A
- Disposable Electrodes—HP M2202A
- Water-resistant adhesive pads
- Adaptor cable—M2472A
- $SpO_2$ Concept Guide*: Understanding Pulse Oximetry*
- $SpO_2$ Sensor Guide
- M2476B 2.5 Ah Battery
- 2 rolls, Thermal Paper—HP 40457C
- Training Video*: Using the HP CodeMaster Portable Defibrillator/Monitor*
- 12-Lead ECG Patient Cable (standard accessory)
- Soft, black carry bag (standard accessory)

## HP M2480B Battery Support System Options/Accessories

Tables 1-18 through 1-21 list available options for the HP M2480B Battery Support System.

**Table 1-19** **M2480B Battery Support System Country Options**

| Option | Country | Labels | Voltage | Frequency |
|---|---|---|---|---|
| ABA | North America | English | 120 | 60 |
| ABB | Europe | English | 220 | 50 |
| ABC | Canada | French | 120 | 60 |
| ABD | Germany | German | 220 | 50 |
| ABE | Spain | Spanish | 220 | 50 |
| ABF | France | French | 220 | 50 |
| ABG | Australia | English | 240 | 50 |
| ABH | Netherlands | Dutch | 220 | 50 |
| ABK | Intercon English | English | 220 | 50 |
| ABM | Latin America | Spanish | 120 | 60 |
| ABN | Norway | Norwegian | 220 | 50 |
| ABP | Switzerland | German | 220 | 50 |
| ABQ | Switzerland | French | 220 | 50 |
| ABS | Sweden | Swedish | 220 | 50 |
| ABU | United Kingdom | English | 240 | 50 |
| ABZ | Italy | Italian | 220 | 50 |
| ACD | Switzerland | English | 220 | 50 |
| ACQ | South Africa | English | 220 | 50 |
| AKL | Thailand | English | 220 | 50 |
| AKM | China | English | 220 | 50 |
| AKV | South America | Spanish | 220 | 50 |

**Table 1-20** **M2480B Battery Support System Power Cord Part Numbers**

| Power Cord Key | HP Part Number |
|---|---|
| NEMA 5-15 2.5M | 8120-5213 |
| CEE 7/7 2M | 8120-1692 |
| CBL-power cord, Australia | 8120-4464 |
| CBL-power cord, INTERCON | 8120-1703 |
| CBL-power cord, German | 8120-2296 |
| CBL-power cord, South Africa | 8120-4600 |
| CBL-power cord, China | 8120-4464 |

**Table 1-21** **M2480B Battery Support System NiCad Battery Options**

| Option | Description |
|---|---|
| C76 | Additional 2.5 Ah NiCad battery. |
| C77 | 4.0 Ah NiCad battery. |

### M2480B Battery Support System Standard Accessories Supplied

- M2476B 2.5 Ah Battery

# Configuration

## General Information

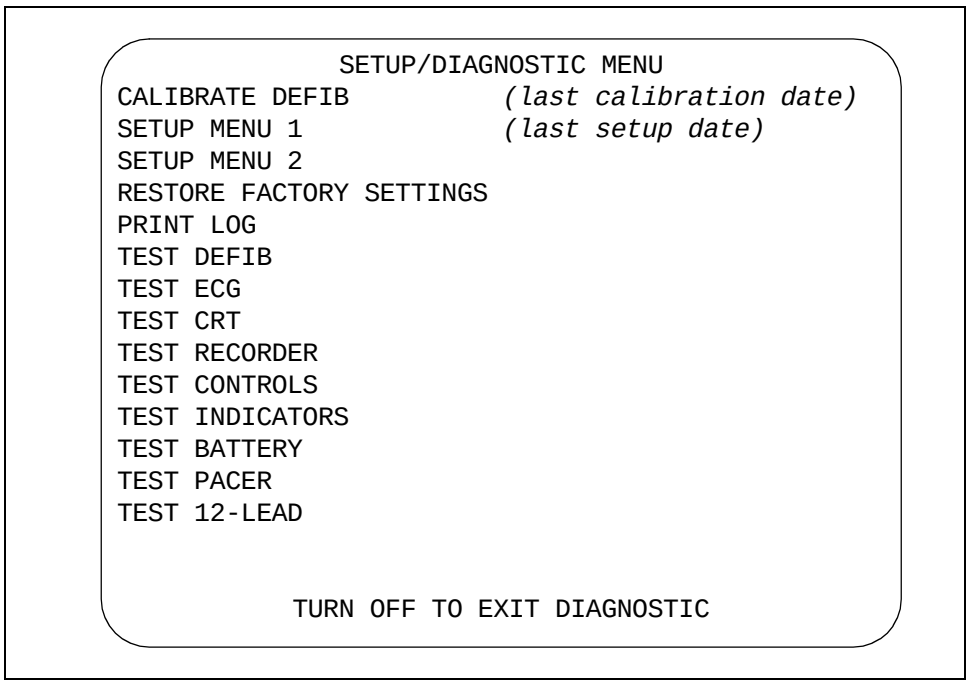
This chapter explains how to display, print, or change the defibrillator configuration settings and the current date and time for the HP CodeMaster 100 Portable Defibrillator/Monitor. A factory-recommended configuration process guides you through the setup menus and describes configuration choices that you can use when assisting customers.

The defibrillator is designed to provide custom operation. Configuration settings let the user program the defibrillator for the most useful and efficient operation. Defibrillator configuration is set at the factory, but should be checked by a qualified technician at initial setup and changed, as desired.

### Displaying the Setup/Diagnostic Menu

To display the setup/diagnostic menu, press both the (Sync) and (HR Alarm) keys while turning the Energy Select control from the Off (Standby) to Monitor On position. A display with a list of choices appears. Figure 2-1 shows the items on the menu.

**Figure 2-1**




**Setup/Diagnostic Menu**

| | |
|---|---|
| `CALIBRATE DEFIB` | Calibrates the defibrillator. The date when calibration was last performed is normally shown to the right. The date disappears if the stored value that the defibrillator test measures is lost. In either case, performing defibrillator calibration puts the test date on the menu. Refer to *Setup/Diagnostic Menu Tests* in Chapter 3 for test information. |
| `SETUP MENU 1`<br>`SETUP MENU 2` | Displays setup menu 1 or 2. The date when either menu was last displayed is normally shown to the right of `SETUP MENU 1`. When factory defaults are restored by the user or because configuration is lost, no date is displayed. Displaying either menu puts the date on the menu. |
| `RESTORE FACTORY SETTINGS` | Changes the configuration settings in the setup menus back to the factory default settings. Exceptions are:<br>• `LANGUAGE` on setup menu 1 (maintains selected language).<br>• System date on setup menu 1 (remains unchanged).<br>• System time on setup menu 1 (remains unchanged).<br>• `SETUP MENU 1` date is cleared.<br>• Stored calibration value (maintains last value measured by Defibrillator Calibration; refer to *Setup/ Diagnostic Menu Tests* in Chapter 3 for test information.)<br>• Shock counter (maintains current count; refer to *The System Log* in Chapter 4 for more information.)<br>• System (error) log (maintains current system log data; refer to *The System Log* in Chapter 4 for more information.)<br>See Figures 2-2 and 2-3 for factory default settings information. |
| `PRINT LOG` | Prints the system (error) log. Refer to *The System Log* in Chapter 4 for more information. |
| `TEST xxxx` | These menu items test defibrillator operation. Refer to *Setup/Diagnostic Menu Tests* in Chapter 3 for test information. |

## Displaying/Printing Configuration Settings

To display or print the configuration settings, follow the steps described in Table 2-1.

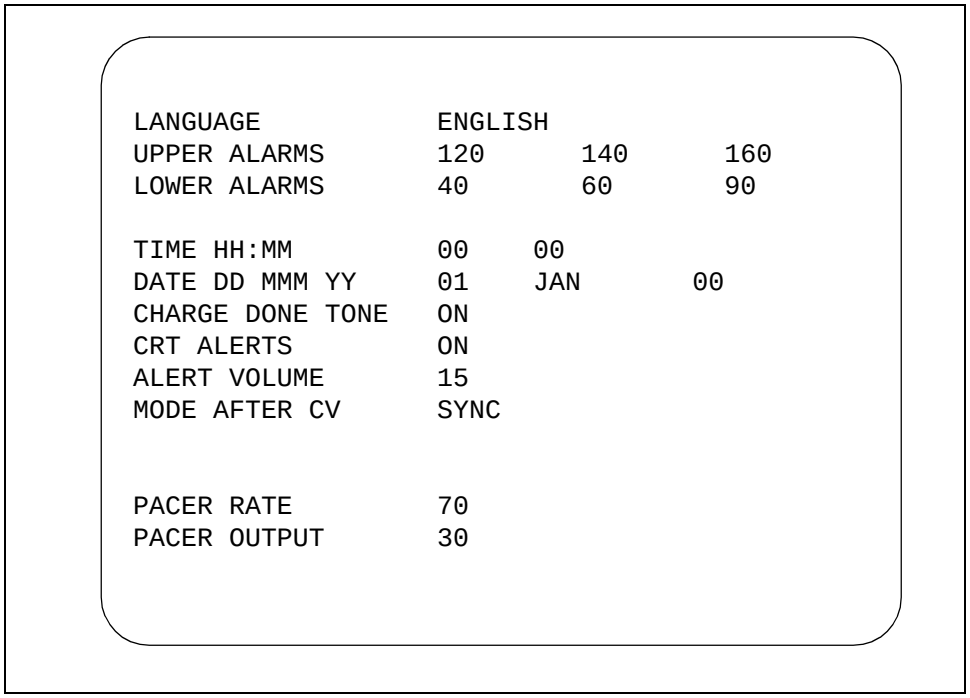
**Table 2-1 Displaying/Printing a Configuration Setting**

| Description | Process |
|---|---|
| Display the setup/diagnostic menu | Press both the (Sync) and (HR Alarm) keys while turning the Energy Select control from **Off (Standby)** to the **Monitor On** position. |
| Highlight the setup menu | Press (▼ ECG Size) or (ECG Size▲) to move the highlight over SETUP MENU 1 or SETUP MENU 2 . |
| Display the setup menu | Press (Lead Select) to select the highlighted menu. The display changes to show the configuration settings in the setup menu you selected. The configuration settings listed in each setup menu are shown in Figures 2-2 and 2-3 |
| Print the current configuration settings | Press (Record). The recorder prints the current settings for SETUP MENU 1 or SETUP MENU 2 . |
| Exit the setup menu | Press both arrows on the (▼ ECG Size▲) key, simultaneously, to return to the main setup/diagnostic menu. |
| Exit setup/diagnostic menu | Turn Energy Select to the Off (Standby) position to exit the setup/diagnostic menu. |

**NOTE**

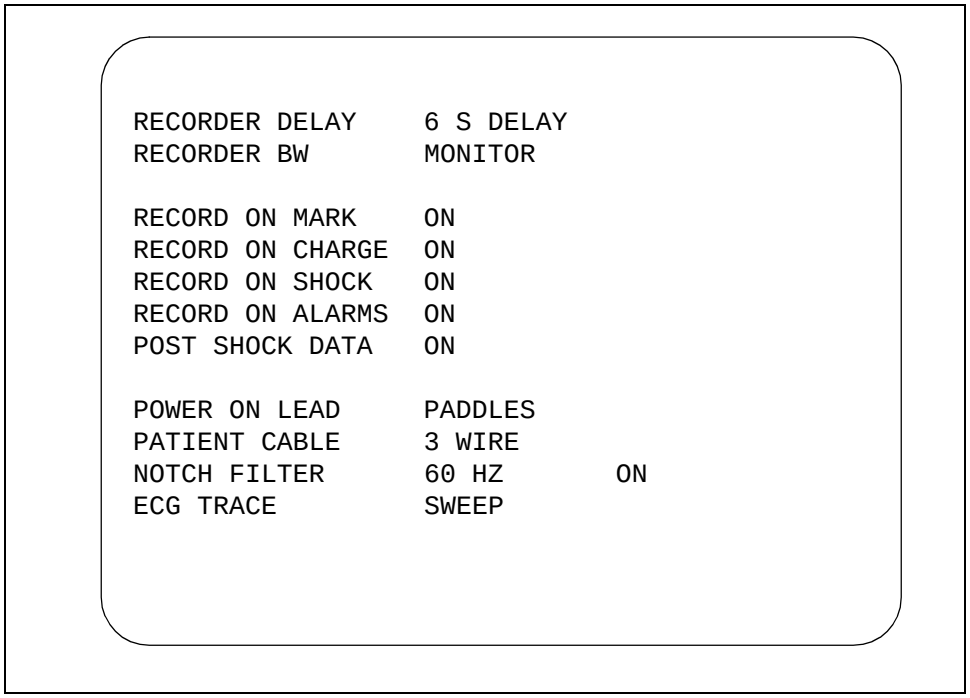
The (▼ ECG Size▲) key has both up and down arrows; pressing ▲ moves the highlight up, and pressing ▼ moves the highlight down.

**Figure 2-2**




**Configuration Default Settings—Setup Menu 1**

**Figure 2-3**


RECORDER DELAY 6 S DELAY
RECORDER BW MONITOR
RECORD ON MARK ON
RECORD ON CHARGE ON
RECORD ON SHOCK ON
RECORD ON ALARMS ON
POST SHOCK DATA ON
POWER ON LEAD PADDLES
PATIENT CABLE 3 WIRE
NOTCH FILTER 60 HZ ON
ECG TRACE SWEEP

**Configuration Default Settings—Setup Menu 2**

To return to the main setup/diagnostic menu, simultaneously press both arrows on the (▼ ECG Size ▲) key.

To exit the menus, turn the Energy Select control to the Off (Standby) position.

## Changing Configuration Settings

To change a configuration setting or to change the current date, use the process described next.

**CAUTION**

The CHECK SETUP message appearing on the screen is an indication that the lithium (backup) battery requires replacement, as described in Chapter 6 of this manual. This backup battery must be maintained to assure that the CodeMaster 100 setup memory is not erased due to inadequate battery voltage.

**WARNING**

**The setting values of some configuration settings can have critical impact on how your defibrillator operates. Because of this, it is recommended that the EMS services standardize on a configuration for all defibrillators at the same facility.**

**If the defibrillator loses your configuration settings, it will display the message SETUP LOST on the screen and use the factory settings for all setup values. To clear the SETUP LOST message, display setup menu 1 or setup menu 2. The "Setup Lost" condition will be cleared when you view the setup menus. You do not have to change the values if you want to keep the factory settings.**

**Table 2-2 Changing a Configuration Setting**

| Description | Process |
|---|---|
| Display the setup/diagnostic menu | Press both the (Sync) and (HR Alarm) keys while turning the Energy Select control from Off (Standby) to the Monitor On position. |
| Highlight the setup menu | Press (▼ ECG Size) or (ECG Size▲) to move the highlight over SETUP MENU 1 or SETUP MENU 2. The configuration settings listed in each setup menu are shown in Figures 2-2 and 2-3. |
| Display the setup menu | Press (Lead Select) to select the highlighted menu. The display changes to show the configuration settings in the setup menu you selected. |
| Highlight the setting you want to change | Press (▼ ECG Size) or (ECG Size▲) until the highlight appears on the setting you wish to change. |
| Select the highlighted setting | Press (Lead Select). |
| Scroll through the possible settings | Press (▼ ECG Size) or (ECG Size▲). |

**Table 2-2 Changing a Configuration Setting (Continued)**

| Description | Process |
|---|---|
| Select the setting | When the choice you want is displayed, press (Lead Select) to set your choice. Repeat this process to change another configuration setting, if desired. |
| Exit the setup menu | Press both arrows on the (▼ ECG Size ▲) key, simultaneously, to return to the main setup/diagnostic menu. |
| Store settings and exit setup/diagnostic menu | Turn Energy Select to the **Off (Standby)** position to store your setting changes in memory and exit the menus. |

Tables 2-3 and 2-4 show the configuration items and list possible settings. You can change the settings back to the default settings by selecting RESTORE FACTORY SETTINGS on the setup/diagnostic menu. Refer to *Displaying/Printing Configuration Settings* earlier in this chapter for information on restoring factory default settings.

**Table 2-3 Configuration Settings—Setup Menu 1**

| Configuration Item | Setting Choices | Comments |
|---|---|---|
| Language | English, Spanish, Italian, German, French, Swedish, Dutch, Norwegian | Selects the language for printed and displayed text. |
| Upper Alarms | From lower alarm limit to 280, in increments of 5 | Sets three upper heart rate limits. |
| Lower Alarms | From 20 to upper alarm limits, in increments of 5 | Sets three lower heart rate limits. In normal operation, one set of limits is displayed and you can cycle through the three limits sets to select the set you want. The first set consists of the upper and lower limits shown on the left in setup menu 1. The second set is the middle setting for each limit. The third set consists of the settings for each limit shown on the right. |
| Time | hh:mm | Sets the current time. |
| Date | dd:mmm:yy | Sets the current date. |
| Charge Done Tone | On or Off | For ON, the defibrillator sounds a continuous tone while it is armed. |
| CRT Alerts | On or Off | For ON, the defibrillator beeps three times when any CRT Alert message is displayed. OFF turns off CRT alerts. |
| Alert Volume | 3 to 15 (loudest) | Selects the volume of CRT Alerts and HR Alarms. |

**Table 2-3** **Configuration Settings—Setup Menu 1 (Continued)**

| Configuration Item | Setting Choices | Comments |
|---|---|---|
| Mode after CV | Sync or Defib | Selects the defibrillator mode after cardioversion. For SYNC, the defibrillator discharges at next R-wave after the user presses both Shock buttons; for DEFIB, the defibrillator discharges only when user presses discharge buttons. |
| **Settings for the pacer: (Shown when pacer is turned on)** | | |
| Pacer Rate | 40 to 180 ppm in increments of 10. | Selects the number of pacer pulses per minute (ppm). |
| Pacer Output | 10 to 200 mA in increments of 10. | Selects the amplitude (level) of the pacer pulses, in mA. |

### Disabling the Internal Pace Pulse Detection Marker

In normal operation, the defibrillator detects internal pace pulses when monitoring with leads. Internal pace pulse detection is indicated on the screen by a negative spike relative to the ECG baseline.

**NOTE**

Regardless of this configuration setting, the machine will continue to reject patient internal pace pulses for heart rate calculation.

To enable or disable the Pace Pulse Marker, press (Sync), (HR Alarm), and (Mark) simultaneously while in Setup Menu 1. To determine if this feature is enabled, print out the system log. Refer to *The System Log* in Chapter 4 for an explanation of the system log.

**Table 2-4** **Configuration Settings—Setup Menu 2**

| Configuration Item | Setting Choices | Comments |
|---|---|---|
| Recorder Delay | 6 S Delay or No Delay | Recorded ECG is delayed 6 seconds after event, or starts printing immediately. |
| Recorder BW | Diagnostic or Monitor Diagnostic Frequency Response is only available when monitoring with leads. | Selects the bandwidth of recorder printout. For DIAGNOSTIC, frequency response is from 0.05 to 150 Hz; for MONITOR, from 0.5 to 40 Hz. |
| Record on Mark | On or Off | For ON, the recorder prints when (Mark) is pressed. |
| Record on Charge | On or Off | For ON, the recorder prints when (Charge) is pressed. |

**Table 2-4** **Configuration Settings—Setup Menu 2**

| Configuration Item | Setting Choices | Comments |
|---|---|---|
| Record on Shock | On or Off | For ON, the recorder prints following a discharge. |
| Record on Alarms | On or Off | For ON, the recorder prints when a heart rate or $SpO_2$ alarm violation occurs. |
| Post Shock Data | Off or On | For ON, recorder prints the delivered (actual) energy statistics. For OFF, recorder prints the Energy Select control setting. |
| Power On Lead | Paddles, Lead I, II, or III | Selects the default ECG monitoring source at power-on. |
| Patient Cable | 3 Wire or 5 Wire | Sets the defibrillator to treat the input as if either a 3-wire or 5-wire patient cable is attached to the ECG Input connector. |
| Notch Filter | 50 Hz or 60 Hz, On or Off | Selects power line filter frequency, and turns filter On or Off. |
| ECG Trace | Sweep or Scroll | Selects the ECG trace style. SWEEP updates the displayed patient data from left to right, and then repeats the update. For SCROLL, the displayed patient data "moves" from the right to left sides of the display. |

# Configuring the 12-Lead Option

This topic provides procedures for configuring the 12-Lead option. Table 2-5 lists the selections available on the Configuration Menu.

**Table 2-5 12-Lead Configuration Menu Settings**

| Menu Selection | Function |
|---|---|
| Setup ID Entry | Identify which patient information fields will be used. Define the text contained in user-defined fields. |
| Setup 12-Lead Settings | Identify ECG lead format and nomenclature used on printed 12-Lead ECG reports |
| Setup ECG Filters | Identify which filters will be used to clarify ECGs in noisy environments |
| Setup Miscellaneous | Set the Institution label; set type of interpretation; set the number of ECG copies printed; set 12-Lead keypad to upper or lower case; set 12-Lead location code and ID. |
| Setup Transmission | Define modem initialization strings, cellular dialing prefix. |
| Setup Gateway | Define telephone number for gateway if a gateway is used. |
| Setup Telephone Directory | Define names, telephone numbers, and type of equipment used at receiving sites. |
| Setup Automated Operations | Enable automatic transmission of ECGs if desired. |

## Navigating the Configuration Menus

When you need to edit the 12-Lead configuration, use the following techniques:

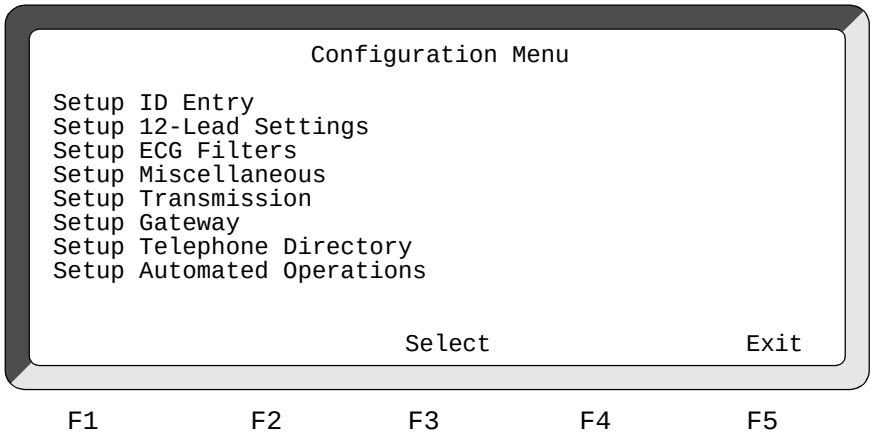
- To enter the 12-Lead configuration menu, press the Menu key on the keyboard.
- To select from a menu, press ▼ to move the cursor down, or press ▲ to move the cursor up until the desired menu line is highlighted, then press ***F3*** to display the selected item.
- To select a field on a data entry screen, press ▼ or ► to move the cursor down, or press ▲ or ◄ to move the cursor up until the desired entry line is highlighted. To save the settings, exit the Configuration menu.
- To change a field, select ***F3*** to step through the choices available.
- To exit the Configuration menu and save your configuration data, press ***F5***.

### Adjusting Display Screen Contrast

Press **Shift** with the ▲ or ▼ key to lighten or darken the contrast on the 12-Lead display.

## Using the 12-Lead Configuration Menu

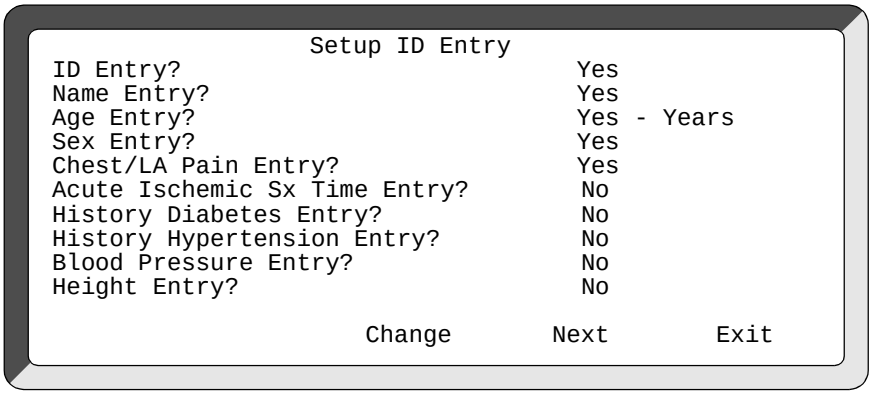
The 12-Lead option can be customized to meet your particular requirements. Using the Configuration Menu, you can choose the screens from which you can set the 12-Lead configuration. When you select Configure 12-Lead from the Main Menu, the Configuration Menu appears:




Each Configuration Menu choice is described briefly in a list, then each is described in more detail in the sections that follow. Default configuration settings are also listed in the tables.

### Setting Up Patient Information

The Setup ID Entry screen allows you to choose the patient identification entries requested prior to recording an ECG. The following screen shows the patient identification entries available for configuration. Enter data for patient information. Use ***F3*** to change the value of a field.




**NOTE**

The patient age, sex and height and weight affect the standard interpretation of the ECG. For the most accurate interpretation, include them in the patient ID entry. At a minimum, enter age and sex. If you do not enter data into these fields, the analysis software or 12-Lead algorithm will use default values for the analysis.

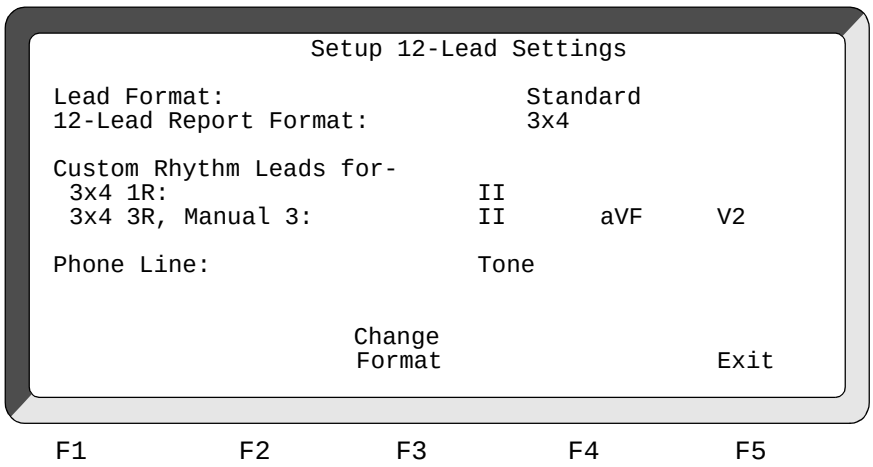
### Setting Up 12-Lead Fields

This screen allows you to choose the default formats that will be used when you power-on the system. Table 2-6 shows the available report formats. Use ***F3*** to change a field.

**Table 2-6 Configurable Report Characteristics**

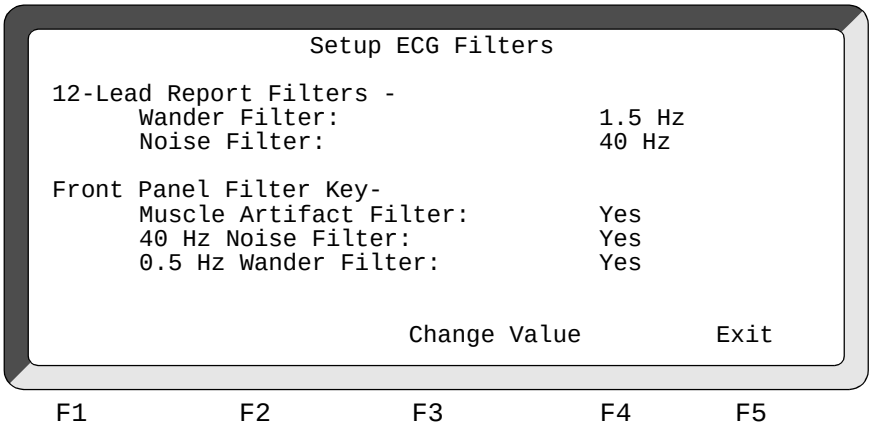
| Parameter | Choices[1] | Comments |
|---|---|---|
| Lead Format | **Standard**<br>Cabrera | |
| 12-Lead Report Format | **3x4**<br>3x4, 1R<br>3x4, 3R | |
| Custom Rhythm Leads for: | | |
| 3x4 1R | I, **II**, III, aVR, aVL, aVF, V1/C1, V2/C2, V3/C3, V4/C4, V5/C5, V6/C6 | Select any lead |
| 3x4 3R, Custom 3 | I, **II**, III, aVR, aVL, **aVF**, V1/C1, **V2/C2**, V3/C3, V4/C4, V5/C5, V6/C6 | Select any V three leads |
| Phone Line | **Tone**<br>Pulse<br>Direct<br>Cell | |

[1]Default values are shown in boldface type.



### Setting Up Filters

From the Configuration Menu, select Setup ECG Filters. The 12-Lead option has been factory-configured with the filter settings which remove the most noise from the ECG. In addition to the default settings, 12-Lead offers a choice of several filter configurations. These filter settings are detailed below and in Table 2-7.




- The 0.5 Hz Baseline Wander filter suppresses the greatest amount of baseline wander.
- The 0.15 Hz Baseline Wander filter provides some baseline wander suppression without distorting the ECGs ST segment.
- The 0.05 Hz Baseline Wander filter delivers the highest fidelity signal, but provides the least baseline wander suppression.
- The 40 Hz Noise filter offers maximum noise suppression, but reduces the fidelity of the signal.
- The 100 Hz Noise filter provides some noise suppression while offering an accurate signal representation.
- The 150 Hz Noise filter delivers the highest fidelity signal, but provides the least high-frequency noise suppression.
- The Muscle Artifact filter will be enabled when the **Filter** key is pressed. It removes small-amplitude, high-frequency signals, characteristic of muscle tremor.

**NOTE**

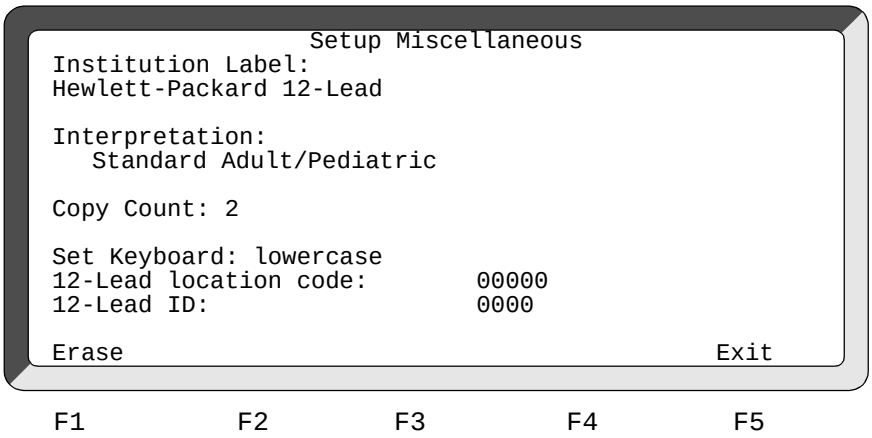
When the front panel Filter key is on, the user-configured combination of the Artifact, 0.5 Hz Wander, and 40 Hz Noise filters is enabled and the `Filter` status message appears in the upper-right corner of the display. Refer to Table 2-7 for information on configuring the **Filter** key.

**Table 2-7 Configurable Filters**

| Parameter | Choices[1] | Comments |
|---|---|---|
| Wander Filter | 0.05 Hz<br>**0.15 Hz**<br>0.5 Hz | Select one baseline wander filter for ECGs. |
| Noise Filter | **40 Hz**<br>100 Hz<br>150 Hz | Select one noise filter for 12-Lead ECGs. |
| Front Panel **Filter** Key<br>Muscle Artifact filter<br>0.5 Hz Baseline Wander filter<br>40 Hz Noise Filter | <br>**Yes** or No<br>**Yes** or No<br>**Yes** or No | Select whether or not the artifact, baseline wander and noise filters are activated by the **Filter** key. |

[1]Default values are shown in boldface font.

**Setting Up Interpretation, Copy Count, Institution Label, and Keyboard Parameters**




***Changing the Institution Label***

The Institution name is printed and transmitted with all ECGs and is displayed at the top of the Main Menu. Press ***F1*** to clear the field, then type a name. There are 30 character spaces available in this field.

***Setting Interpretation Values***

Interpretation values determine which analysis is applied to an ECG report. The settings are:

| | |
|---|---|
| None | Selecting None disables printing of all computer generated interpretation of the ECG. The waveform prints along with the following fields: Patient ID, Patient Name, Date and Time |
| Measurements Only | Selecting this setting provides an additional page containing the basic measurements and all entered ID fields. Basic measurements are defined in Chapter 6, “Using the 12-Lead Option” of the *HP CodeMaster 100 Portable Defibrillator/Monitor User’s Guide* . |
| Standard Adult/Pediatric | Selecting this setting prints waveform, patient ID, basic measurements summary, and standard adult or pediatric (depending on age entered) computer generated diagnostic statements. |
| ACI-TIPI | Selecting ACI-TIPI provides waveform, patient ID, basic measurements summary, all available patient demographics and computer calculated probability of acute cardiac ischemia. |
| TPI | Selecting TPI provides waveform, patient ID, basic measurements summary, all available patient demographics and predicts patient outcomes (mortality) with and without administering thrombolyties. |

***Setting Copy Count***
Determines how many copies are printed when you press the **Copy** key. You can enter a value from 1-4. The default value is 2.

***Setting Keyboard Values***
Keyboard mode determines whether characters will be entered in uppercase or lowercase. Press *F3* to change from lowercase to UPPERCASE and vice versa. The keyboard is initially set to lowercase. Use the shift key to enter the opposite case.

***Setting 12-Lead Location Code***
The 12-Lead location code identifies a specific department or EMS Service that acquired the ECG. The number prints at the bottom of the report. If set to zero (default), this field will be suppressed from the printed report. This parameter can be any five digit numeric code.

***Setting 12-Lead ID***
The 12-Lead ID code identifies the particular CodeMaster 100 unit that was used to acquire the ECG. The number prints at the bottom of the report. If set to zero (default), this field will be omitted from the printed report. This parameter can be any four digit numeric code.

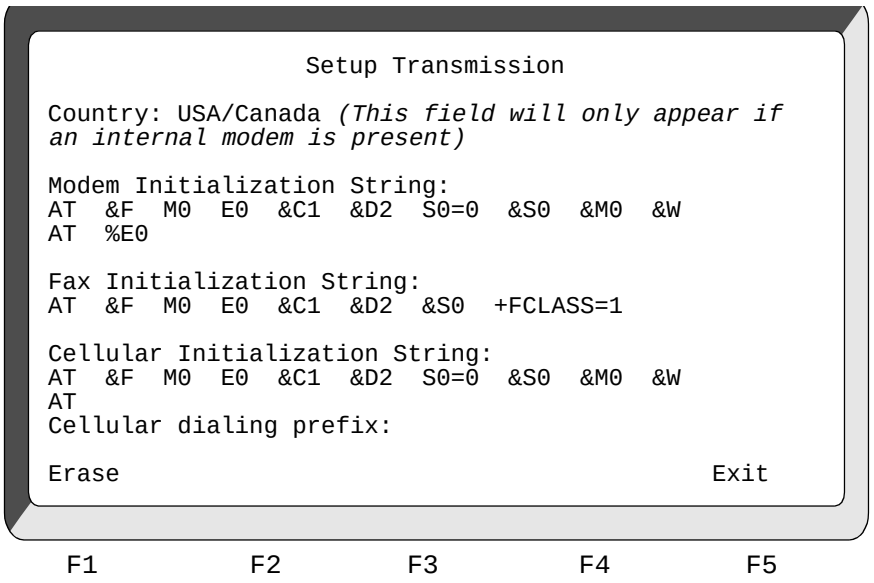
### Setup Transmission

This menu allows the configuration of both the internal and an external modem. Note that your CodeMaster 100 with the 12-Lead option is pre-configured using Hayes™-compatible settings. Hewlett-Packard recommends that you not change any default settings if you are using the internal modem or a Hayes-compatible external modem.

**NOTE**

You must select the correct country to ensure compliance with telecom regulatory standards.

Modem initialization string is used for modem initialization commands **only** and should not contain dialing information. Fax initialization string is used for fax initialization commands **only** and should not contain dialing information. Cellular initialization string is used for cellular initialization commands **only** and should not contain dialing information.



**Setup Transmission Fields**
The modem initialization strings are sent from the 12-Lead option to the modem before dialing begins. This string must be present before sending ECGs using the modem. There is a string for landline, fax, and cellular communications.

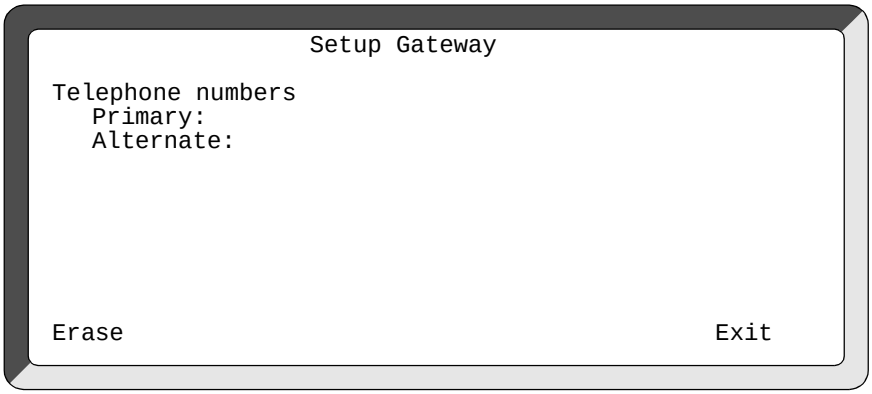
**Cellular Dialing Prefix**
If the receiving modem does not support MNP-10EC cellular enhanced protocol, an optional prefix may be used to enable data transfer over the cellular phone via your service provider's modem pool. This prefix may be obtained from your cellular service provider.

**Setup Gateway**
The Gateway is where the ECG Manager PC gateway resides. To setup the ECG Manager gateway function, configure the Gateway in the Setup Gateway field.

You can configure the ECG Manager gateway by entering phone numbers on the Telephone Directory screen. After an ECG is acquired from the patient, it can be transmitted through the ECG Manager gateway by pushing the **Send** key. Select the desired final destination site on the Telephone Directory screen. This is the site where the ECG Manager gateway will forward the ECG report, automatically. These ECGs can also be autoforwarded to other destinations set up in the telephone directory.

During the transmission process, the HP CodeMaster 100 will dial the Gateway phone number and transmit the ECG report along with the phone number of the final destination.

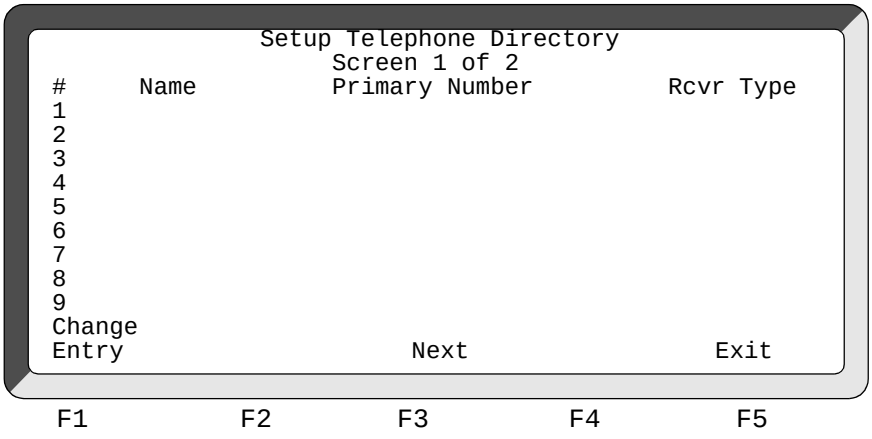
In the Gateway Setup menu, there are two telephone fields: Primary and Alternate. The Primary field will be the first Gateway number dialed. If this number fails, the Alternate gateway number will be used. The Alternate field can be left blank if no alternate gateway number is available.



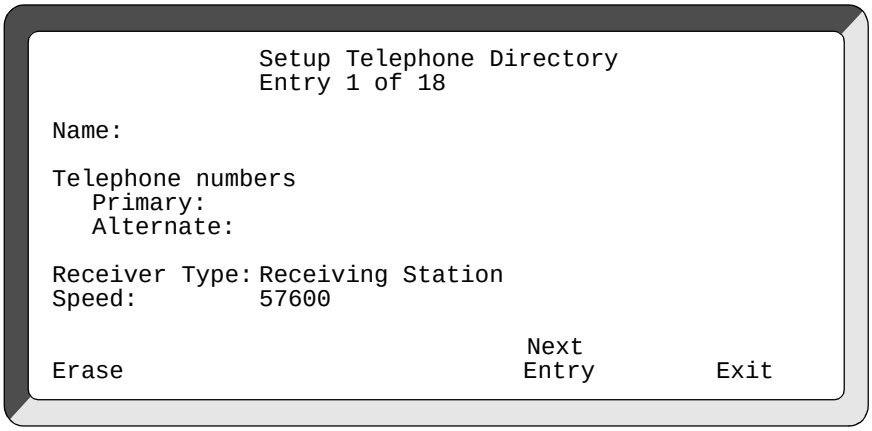
### Setting Up the Telephone Directory

To transmit ECGs, you must identify the receiving site, its telephone number and the type of transmission to send. You can enter the telephone numbers of up to 18 sites in the directory. To setup the telephone directory, perform the following steps:

**1** From the Configuration Menu, press ***F3*** to select `Setup Telephone Directory`.




**2** Press ***F1***. The system displays the setup fields for this directory entry.




**3** Enter the name, primary and alternate telephone numbers, receiver type, and speed. Press ▼ or ▲ to move the cursor to a blank field line.

Note that the modem ignores spaces and hyphens in the telephone number. Use the following special symbols to specify how you want the modem to dial the telephone number:

- **comma(,):** causes the modem to pause for two seconds before continuing to dial.

- **W:** causes the modem to wait for a second dial tone before continuing to dial. Use this symbol if you have to dial 9, wait for a dial tone, and then dial the telephone number to place a call outside your house telephone system.

- **P:** indicates pulse dialing (with a rotary dial), instead of tone (with a keypad).

For example, if you are using a pulse telephone with your modem, and your house telephone system requires dialing a 9 before placing an outside call, you would enter the telephone number as:

P9W5553334444

**4** Select the transmission type by pressing ***F3*** until the appropriate transmission type appears. The transmission type will cycle through `Receiving Station, Fax, TraceMaster A/B, PageWriter XLi, PageWriter 200/300, Other SCP-HP1, Other DT, Event Summary`. `Event Summary` is the **only** transmission type displayed if configuring entries 10-18 (Screen 2 of 2).

**5** Select the transmission speed for your transmission type by pressing ***F3*** until the appropriate transmission speed appears. The following table shows the recommended transmission speed for each type of transmission. Your equipment may require a different speed.

**Table 2-8 Remote Sites, Transmission Types, and Recommended Speeds**

| Receiver Type | Recommended Speed |
|---|---|
| TraceMaster | 2400<br>9600 |
| PageWriter XLi | 2400 |
| PageWriter 200/200i/300pi | 2400 |
| PC Running ECG Manager | 19200 |

**6** Press ***F5*** twice to exit the directory and return to the Configuration Menu.

### Setup Automated Operations

This field allows you to configure the steps to send ECGs after acquisition.

If you enter Yes into this field, the device will automatically go to the telephone directory immediately after an ECG is acquired. In this case, you will not be required to push the Send button until after you have selected the site for which the ECG is to be sent. This automated function removes one step in the process for sending an ECG.

If you enter No into this field, the instrument will return to the Home screen after an ECG is acquired. To send an ECG, you will always be required to push the **Send** button to enter into the telephone directory. Once you are in the telephone directory, select the site for which the ECG is to be sent and push the **Send** button again.

# Performance Verification and Maintenance

## Introduction

This chapter describes the tests and inspection required to verify performance of and maintenance procedures for the HP CodeMaster 100 Portable Defibrillator/Monitor. The information is presented in the following sequence:

| | |
|---|---|
| **Test Results Matrix** | An overview of performance and safety tests. The matrix defines expected CodeMaster 100 test results. |
| **Setup/Diagnostic Menu Tests** | Descriptions of built-in Setup/Diagnostic Menu Tests to calibrate the defibrillator and do quick operational checks. |
| **Performance Verification** | Step-by-step procedures that explain how to test and verify CodeMaster 100 performance |
| **Preventive Maintenance** | Descriptions of routine preventive maintenance procedures that should be performed at least every six months. |
| **Test Equipment** | A list of commercially available test, calibration and simulation boxes needed to perform performance verification tests; plus how to access the Setup/Diagnostic test menu[1] that resides within the CodeMaster 100. |
| **Performance Verification Checklist** | A list to record performance verification results and comments. |

[1] For simple checking without using external equipment, you can use the menu-driven tests built into the defibrillator. However, these tests are not as thorough as the tests that require use of external test equipment.

### Mandatory Testing

All performance verification tests outlined in Table 3-1 must be performed following any service procedure performed on the CodeMaster 100. In addition to testing after servicing, instrument recalibration is always recommended should any of the following events occur:

- If the user suspects that the defibrillator is delivering an energy level lower than the level selected via the Energy Select control.
- If the `CALIBRATE DEFIB` date on the main setup/diagnostic menu is no longer displayed. Refer to Chapter 2, *Displaying/Printing Configuration Settings* for information about the menu. (Note that the defibrillator is shipped with no date displayed).
- If the `SETUP LOST` message is displayed on the screen. Refer to Chapter 2, *Changing Configuration Settings* for information about the message.

## Test Results Matrix

The matrix in Table 3-1 summarizes performance verification for the CodeMaster 100; including test name, test or inspection to perform, expected test results, and data to record. Auxiliary function tests include the CRT Test, the Recorder Test, the Controls Test, and the Indicator Test. Parameter function tests include the SpO2 Test (if option is installed), the HR Alarm Test, the ECG Simulation Test, and the Synch Cardioversion Test. The sections that follow explain the individual tests and inspections in detail.

For a daily check of the defibrillator, refer to *Operation Checks* in the *HP CodeMaster 100 Portable Defibrillator/Monitor User's Guide*.

**Table 3-1 Performance Verification Test Results Matrix)**

| Test Block Name | Test or "Inspection" to Perform | Expected (Passing) Test Results | Data to Record x=P (pass) or F (fail) |
|---|---|---|---|
| **Visual Inspection** | • Inspect the unit—including battery (or battery pocket), recorder, electrodes, and cables or connectors—for signs of wear, damage, or corrosion<br><br>• Using only battery power, cycle power off and on; verify indicator light functionality | • No apparent wear, damage or corrosion:<br><br>• *Battery Charge* light momentarily; *Charge*, *Sync* and *Pacer On* light momentarily | V:x<br><br>*example:*<br>*V:p* |
| **Calibration** | Calibrate defibrillator from the setup/diagnostic menu | Message displayed: "Calibration passed" | C:x<br><br>*example:*<br>*C:p* |
| **Defibrillator Test (DT)**<br><br>(conduct these tests in setup/diagnostic mode) | Using only battery power, set Energy Select to 100; test:<br><br>• MSec. to charge - aaaa<br><br>• Delivered Energy - bbb<br><br>• Impedance - cc<br><br>• Peak Current - dd<br><br>Using only battery power, set Energy Select to 360; test:<br><br>• MSec. to charge - eeee<br><br>• Delivered Energy - fff<br><br>• Impedance - gg<br><br>• Peak Current - hh<br><br>Conduct Disarm Test (charge to 360; disarm) - m | <br><br>• <2000<br><br>• 100+/- 15%<br><br>• 50 Ohm +/- 10%<br><br>• 30 A +/- 10%<br><br><br><br>• <5000<br><br>• 360+/- 15%<br><br>• 50 Ohm +/- 10%<br><br>• 55 A +/- 10%<br><br>“Defib Disarmed” displayed on screen | DT:aaaa,bbb,cc,dd, eeee,fff,gg,hh,m<br><br>*example:*<br>*DT:1300,100,50, 30,3600,360,50, 55,p* |

| **Test Block Name** | **Test or "Inspection" to Perform** | **Expected (Passing) Test Results** | **Data to Record x=P (pass) or F (fail)** |
|---|---|---|---|
| **ECG Tests (E)** | Check:<br>• Leads Status, Paddle Status, and DSP Status - x<br>• DC Offset - aaa<br>• ECG Leads gain (Diagnostic) - bbbb<br>• ECG Lead gain (Monitor) - cccc<br>• ECG Paddles gain (Monitor) - dddd<br>• PCI Calibration<br>o paddles shorted - e<br>o paddles in pocket - fff | <br>"Good" displayed on screen<br>XXX mV<br>1000+/- 10%<br>1000+/- 10%<br>1000+/- 10%<br><br>• 0+/-2 ohms<br>• 20 - 100 ohms | E:x, aaa,bbbb,cccc,dddd, e,fff<br>*example: E:p,0,800,800,800,1,60* |
| **Auxiliary Function Tests (A)** | Conduct the following tests:<br>• CRT Test<br>• Recorder Test<br>• Controls Test<br>• Indicator Test<br>• 12-Lead | "Pass" displayed on screen for all tests | A:x<br>*example: A:p* |
| **Shock Advisory Test (SA)** | Conduct the following tests:<br>• Apply normal ECG<br>• Simulate Systole<br>• Apply VF (Ventricular Fibrillation) rhythm | <br>• "No Shock Advised" printed on ECG strip.<br>• "No Shock Advised" printed on ECG strip.<br>• "Shock Advised" printed on ECG strip. | SA:x<br>*example: SA:p* |

| **Test Block Name** | **Test or "Inspection" to Perform** | **Expected (Passing) Test Results** | **Data to Record x=P (pass) or F (fail)** |
|---|---|---|---|
| **Pacer Test (PT)** | Conduct the Pacer Test with:<br><br>• Selected Output set to 40mA - aa<br><br>• Selected Output set to 100mA - bbb | <br><br>• Delivered mA is 40mA +/- 5%<br><br>• Delivered mA is 100mA +/- 10% | PT:aa,bbb<br><br>*example: PT:40,99* |
| **Parameter Function Tests (F)** | Conduct the following tests:<br><br>• SpO2 Test (if option is installed)<br><br>• HR Alarm Test<br><br>• ECG Simulation Test<br><br>• Sync Cardioversion Test | <br><br>• SpO2 option is functional<br><br>• HR alarm sounds at alarm setting<br><br>• leadwires integrity verified; gain settings accurate<br><br>• cardioversion delay time is less than 60 ms | F:x<br><br>*example: F:p* |

| **Test Block Name** | **Test or "Inspection" to Perform** | **Expected (Passing) Test Results** | **Data to Record x=P (pass) or F (fail)** |
|---|---|---|---|
| **Safety Tests(S)** | Indicate Test conditions as follows:<br>External Pads, Paddles aa=BF<br>Internal Paddles aa=CF<br><br>Check:<br><br>• Chassis-to-Ground Resistance (Main voltage applied)- bbb<br><br>• Ground wire Leakage Current Normal Condition) - ccc<br><br>• Ground wire Leakage Current (Single Fault) - dddd<br><br>• Patient Lead Leakage Current<br>o Source (Normal Condition) - eee<br><br>o Source (Single Fault Condition) - ffff<br><br>o With Mains on applied part (Normal Condition) - gggg<br><br>o With Mains on applied part (Single Fault condition) - hhh<br><br>o Auxiliary (Normal Condition) - iii<br><br>o Auxiliary (Single Fault Condition) - jjj<br><br>Note: All leakage current tests are Normal and Reverse Polarity Conditions | <br><br>• ≤200 mΩ<br><br>• ≤ 500 uA (≤ 300 uA UL)<br><br>• ≤ 1000 uA<br><br>CF/ BF Applied Parts<br>• ≤ 10 uA/100 uA<br><br>• ≤ 50 uA/5000 uA<br><br>• ≤ 10 uA/100 uA<br><br>• ≤ 50 uA/5000 uA<br><br>• ≤ 10 uA/100 uA<br><br>• ≤ 50 uA/500 uA | S:aa, bb, ccc, dddd, eee, fff, gggg, hhh, iii<br><br>*example: S:BF,09,400,700,90, 400,700,16,250* |
| *Note: When recording test results, separate tests by a semi-colon(;). For example: V:p;PO:p;C:p;DT:1300,100,50,30,3600,360,50,55,p;E:p,0,800,800,800,1,60;A:p;SA:p; PT:40,99;F:p;S:BF,09,400,700,90,400,700,16,250* | | | |

# Setup/Diagnostic Menu Tests

The Setup/Diagnostic Menu, internal to the M2475B CodeMaster 100 defibrillator, provides a built-in test tool that can be displayed at the instrument display prior to performing many of the performance verification tests. Using this built-in tool you can perform:

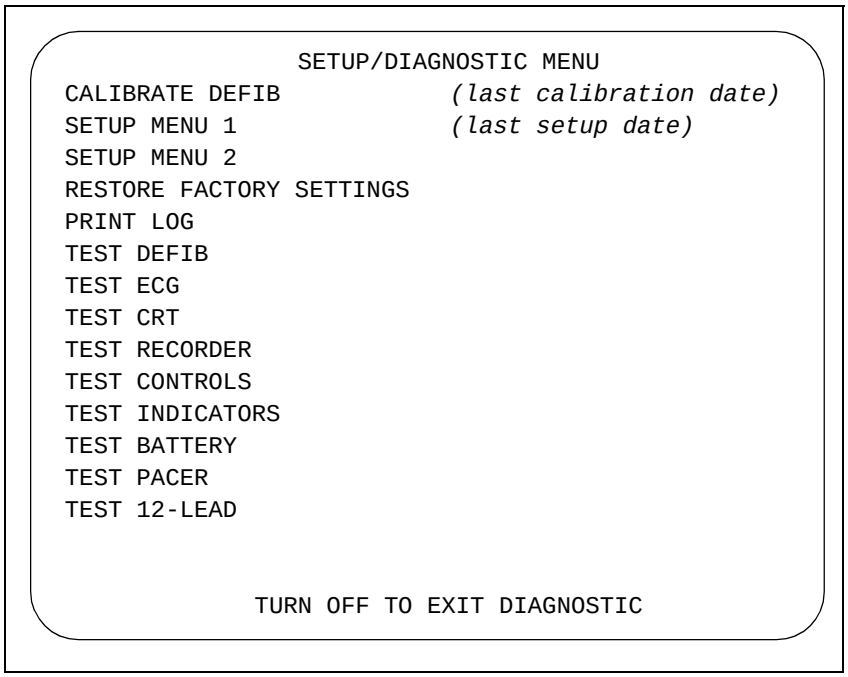
- Defibrillator Calibration
- Energy Tests
- ECG Tests
- Auxiliary Function Tests: (CRT, Recorder, Controls and Indicator Tests, 12-Lead)
- Shock Advisory

The auxiliary function tests require visual verification of displayed or printed output. For these tests, visible failure symptoms appear in the displayed or printed test information, or are shown by indicator operation. For other tests, you determine whether a test has failed by examining test-results data shown on the display.

The setup/diagnostic tests do not test the patient electrodes or the 3- or 5-wire patient cables. You can test the patient electrodes and cables by recording an ECG from a patient or ECG simulator (refer to *ECG Simulation* later in this chapter) or from using the patient cable test tool (M3710-80030).

To access the setup/diagnostic menu tests, turn the Energy Select control to Monitor On, while pressing the (Sync) and (HR Alarm) keys. The display shown in Figure 3-1 appears:

**Figure 3-1**




**Setup/Diagnostic Menu**

The dates appear only if the unit has already been calibrated and the configuration has been set up. See *Changing Configuration Settings* in Chapter 2 for detailed information.

The setup/diagnostic menu lists the built-in tests and other items. With the panel keys, you step through the menu items and select tests. When you select a test, the display changes to show test information. Table 3-2 describes how to use the panel keys to select and start the built-in tests. Additional information concerning each built-in test is provided in the detailed procedures which follow in this chapter.

**Table 3-2** **Performing a Setup/Diagnostic Test**

| Description | Process |
|---|---|
| Highlight the setup/diagnostic menu test | Press (▼ ECG Size) to highlight the test name in the menu. |
| Select the test | Press (Lead Select) . For some tests, the test that you selected then starts running, and repeats until you stop it. For other tests, the display changes to show test patterns or other test information. |
| Perform the test | Follow the instructions in this chapter for the test you selected. |
| To stop a test or return to the setup/diagnostic menu | Press both arrows on the (▼ ECG Size▲) key simultaneously. |
| To exit the setup/diagnostic menu or exit a test | Turn the Energy Select control to Off (Standby). |

# Performance Verification

Verify the performance of the defibrillator every six months and after servicing. The procedures listed below make up performance verification. The performance verification checklist at the end of this chapter summarizes the tests you should perform to verify the defibrillator's performance. These are some suggested uses for this checklist:

- Make copies of the blank checklist; then, fill out a copy each time the defibrillator is tested.
- Attach the recorder test output, simulator ECG trace, and error log printout to the completed checklist and file with the defibrillator's permanent maintenance record.

## Visual Inspection

Before beginning the inspection, turn the Energy Select control to **Off (Standby)** and remove the battery. Then inspect the defibrillator for the following:

- Loose or missing hardware
- Mechanical damage
- Wear of or damage to battery or battery pocket
- Worn recorder drive gear
- Worn recorder roller

## Defibrillator Calibration

When the defibrillator charges, it uses a measured value for the capacitance of the charge capacitor to determine the energy required to reach the selected charge level. The `CALIBRATE DEFIB` choice on the Setup/Diagnostic menu guides the user through a routine that measures the capacitance of the defibrillator capacitor, and adjusts the capacitance value based on the routine's results. The capacitance value is stored in battery-maintained memory and used each time the defibrillator is charged. On the `TEST DEFIB` screen, the stored capacitance value is displayed after `CAPACITANCE`.

**WARNING**

**Avoid touching any metal surfaces on the defibrillator and do not touch equipment connected to the defibrillator during shock. Dangerous high voltage exists on the paddles when the defibrillator is discharged. Contact with this high voltage could cause death or serious injury.**

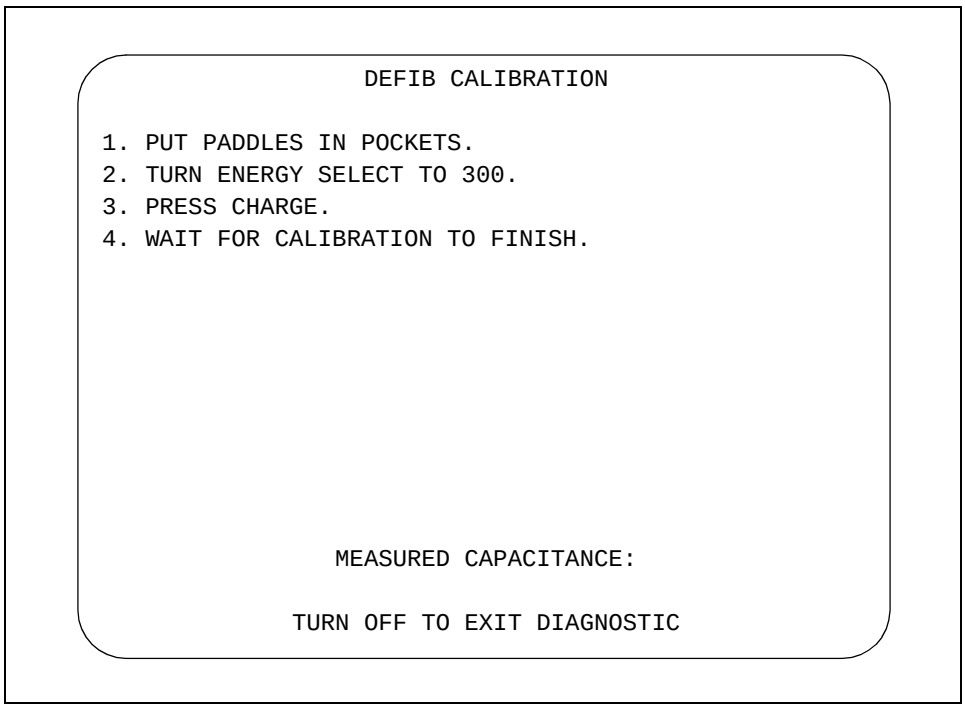
### Test Prerequisites

Connect the external paddles and place them firmly in their holders in the defibrillator.

### Calibrating the Defibrillator

To start the defibrillator calibration routine, select `CALIBRATE DEFIB` on the setup/diagnostic menu; the screen displays the information shown in Figure 3-2.

**Figure 3-2**


DEFIB CALIBRATION
1. PUT PADDLES IN POCKETS.
2. TURN ENERGY SELECT TO 300.
3. PRESS CHARGE.
4. WAIT FOR CALIBRATION TO FINISH.
MEASURED CAPACITANCE:
TURN OFF TO EXIT DIAGNOSTIC

**Calibrate Defibrillator Screen**

Follow the instructions displayed on the screen. (If you set the Energy Select control to a level below 300 joules, the message, `BAD USAGE: SEE MANUAL` is displayed.)

If the test completes successfully, `CALIBRATION PASSED` is displayed at the bottom of the screen. If the test fails, `CALIBRATION FAILED` is displayed and the nominal capacitance value is used; refer to Chapter 4, *Troubleshooting*, for detailed information.

## Defibrillator Test

This test verifies defibrillator performance to specifications. You should run the Defibrillator Calibration routine before performing the defibrillator test. You can perform the defibrillator test using either external paddles or pads.

**WARNING**

**If using pads adapter cable M2472A, connect an M1781A test load when performing the defibrillator test.**

### Test Prerequisites

Connect the external paddles and place them firmly in their holders in the defibrillator, or attach the M1781A test load if you are using pads. The battery must be fully charged.

### Testing the Defibrillator

This test is designed to check the defibrillator with a fully charged battery installed.

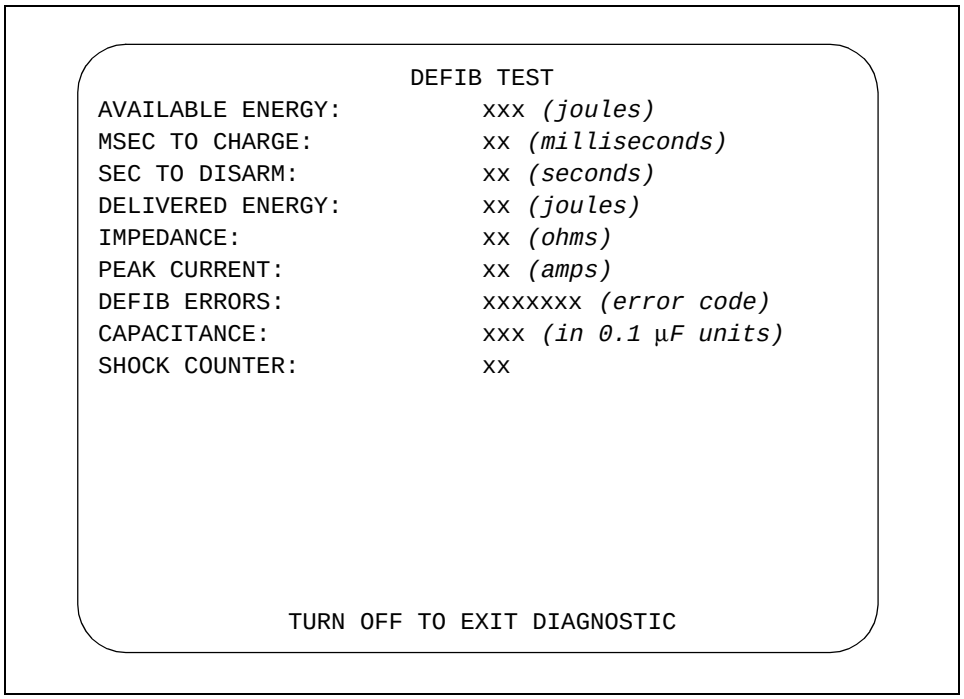
Run the test at 100 and at 360 joules. The values of some test results vary depending on the energy used. Table 3-4 lists acceptable test result values for the energy setting. You should test the disarm function as described at the end of the defibrillator test.

To run the defibrillator test, follow these steps:

**1** Make sure that the battery is fully charged.

**2** Select `TEST DEFIB` in the setup/diagnostic menu; the screen displays the information shown in Figure 3-3. This figure shows defibrillator performance parameters. Some of these parameters are not available until after the defibrillator is discharged.

**Figure 3-3**


DEFIB TEST
AVAILABLE ENERGY: xxx (joules)
MSEC TO CHARGE: xx (milliseconds)
SEC TO DISARM: xx (seconds)
DELIVERED ENERGY: xx (joules)
IMPEDANCE: xx (ohms)
PEAK CURRENT: xx (amps)
DEFIB ERRORS: xxxxxxx (error code)
CAPACITANCE: xxx (in 0.1 μF units)
SHOCK COUNTER: xx
TURN OFF TO EXIT DIAGNOSTIC

**Defibrillator Test Screen**

| | |
|---|---|
| AVAILABLE ENERGY: | Current charge in joules; 0 when the defibrillator is not armed. |
| MSEC TO CHARGE: | After the defibrillator charges to the energy level selected, the entry shows how many milliseconds the charge required. |
| SEC TO DISARM: | After the defibrillator signals Charge Done, it holds the charge for 60 seconds, and then starts disarming the charge through an internal safety relay. The entry shows the time required to disarm the defibrillator to the “safe” state. |

| | |
|---|---|
| DELIVERED ENERGY: | The calculated delivered energy (in joules) based on the internal peak current measurement. |
| IMPEDANCE: | The calculated load impedance based on available energy and the internal peak current measurement (in Amps). |
| PEAK CURRENT: | The peak current measured during defibrillator discharge. |
| DEFIB ERRORS: | Defibrillator errors that have occurred while in diagnostic test mode. |
| CAPACITANCE: | The capacitance used when charging the defibrillator. The capacitance value is established during Defibrillator Calibration (refer to *Defibrillator Calibration* earlier in this chapter for information). |
| SHOCK COUNTER: | The number shown is the number of shocks since the shock counter was reset. You can clear the shock counter by pressing the (Sync) and (HR Alarm) keys simultaneously, while displaying this screen. Only clear the shock counter after replacing a patient relay/inductor component, such as the defibrillator capacitor, high voltage inductor, patient relay, or high voltage charger board. Record the value of the shock counter prior to clearing it. |

**3** Turn the Energy Select control to the desired energy level.

**4** Press (Charge). The value for AVAILABLE ENERGY increments.

**5** Check that it reaches the energy level you selected, when the Charge Done LED is lit on the front panel or the apex paddle.

**6** Check that the entry for MSEC TO CHARGE is within the limits listed in Table 3-3 for the energy setting you selected.

**Table 3-3 Defibrillator Test Limits**

| Defibrillator Configuration | Available Energy | MSec to Charge | Sec to Disarm | Delivered Energy | Impedance | Peak Current |
|---|---|---|---|---|---|---|
| **Battery Only** | 100 j | < 2000 | – | 85–115 J | 45–55Ω | 26–33 A |
| | 360 j | < 5000 | – | 306–414 J | 45–55Ω | 50–60 A |
| **Disarm Test** | 360 j | – | < 7 sec | | | |

**WARNING**

**Avoid touching any metal surfaces on the defibrillator and do not touch equipment connected to the defibrillator during shock. Dangerous high voltages exist on the paddles when the defibrillator is discharged. Contact with this high voltage could cause death or serious injury.**

**7** Discharge the defibrillator by pressing the two shock buttons.

**8** Check that the values for DELIVERED ENERGY, IMPEDANCE, and PEAK CURRENT are within the limits listed in Table 3-4.

**To test the automatic disarm function:**

**9** Press (Charge) again.

**10** Wait until an alternating tone sounds, and then the AVAILABLE ENERGY value decrements to 0.

**11** Repeat the test for the other energy level, if desired.

**To test the manual disarm function:**

**12** Turn the Energy Select control to 360 joules.

**13** Press (Charge).

**14** When the charge reaches 360 joules, turn the Energy Select control directly to **Monitor On**. Turn the control quickly and do not stop at any level selection between 360 joules and the **Monitor On** position. This step disarms the defibrillator.

**15** Check that the SEC TO DISARM value displayed on the screen is within the limits listed in Table 3-4.

**16** Press both sides of (▼ECG Size▲) at once to exit the test menu.

## Delivered Energy Level Test

To perform the delivered energy level test, you need a test box. See Table 3-5 for equipment specifications. The test checks that the delivered discharge energy measured by the test box is equivalent to the charge level displayed on the defibrillator.

To verify the delivered energy level, follow the instructions provided with the test box. See Chapter 1, Table 1-4.

**WARNING**

**Avoid touching any metal surfaces on the defibrillator and do not touch equipment connected to the defibrillator during shock. Dangerous high voltage exists on the paddles when the defibrillator is discharged. Contact with this high voltage could cause death or serious injury.**

## ECG Tests

This test verifies the operation of the leads and paddles ECG front end amplifiers, and checks digital signal processor filtering. The test also verifies communication between the ECG front end/pacer board and the control board.

### Test Prerequisites

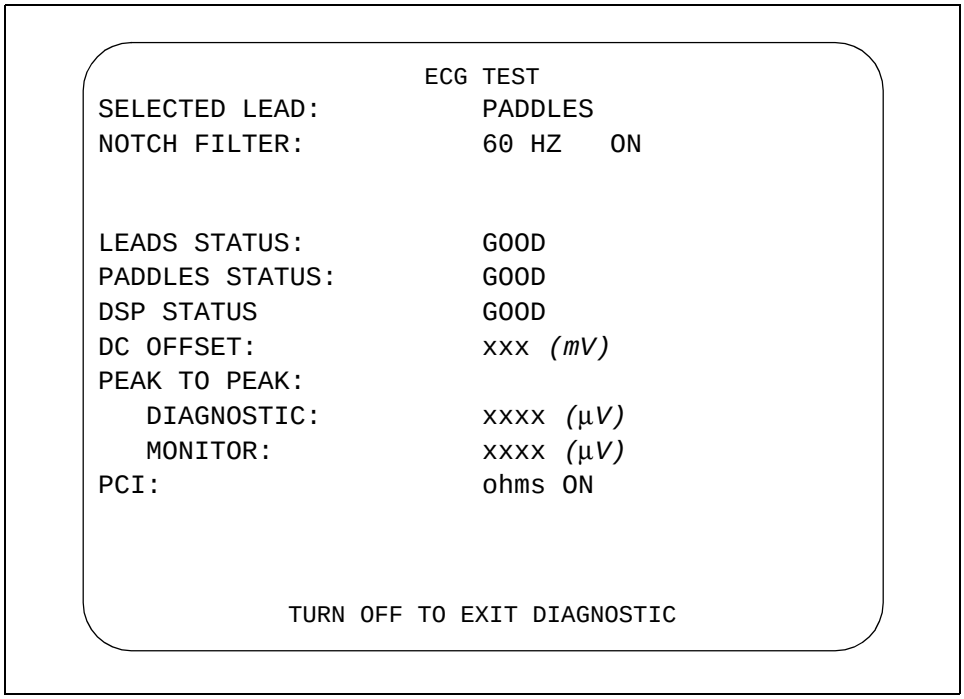
This test requires a calibrated ECG simulator for use with pads and leads, and it requires an AAMI simulated patient load. Refer to *Test Equipment* earlier in this chapter for equipment information.

### Testing the ECG Monitor

To run the ECG test, follow these steps:

**1** Select TEST ECG in the setup/diagnostic menu; the display shows the information shown in Figure 3-4.

**Figure 3-4**




**ECG (Monitor) Test**

| | |
|---|---|
| SELECTED LEAD: | Lets you select the ECG source. |
| NOTCH FILTER: | Current power line filtering frequency: 50 or 60 Hz; you can change the filtering and turn the filter off and on. |
| LEADS STATUS: | GOOD indicates that communication between the Leads Front End and DSP is acceptable. |
| PADDLES STATUS: | GOOD indicates that communication between the Paddles/Front End and DSP is acceptable. |
| DSP STATUS: | GOOD indicates that the DSP is communicating properly with the monitor. |
| DC OFFSET: | An offset value used when measuring Leads Off. Largest absolute value offset of any wire used in lead combination according to the lead selected (mV). |
| PEAK TO PEAK DIAGNOSTIC: MONITOR: | Peak-to-peak signal of the SELECTED LEAD measured over a one-second interval. Results are given for both MONITOR (0.5Hz to 40 Hz) and DIAGNOSTIC (0.05Hz to 150 Hz) bandwidth. |

| | |
|---|---|
| PCI: | Paddles impedance measured in ohms. Used to determine PADDLES OFF, and for PCI (paddles contact indicator) bar graph on sternum paddle. Patient impedance can be calibrated. Refer to *PCI Calibration* later in this chapter for instructions. PCI ON indicates that displayed data is calibrated. PCI OFF indicates that displayed data is not calibrated. |

**2** Check that LEADS STATUS is GOOD.

**3** Check that PADDLES STATUS is GOOD.

**4** Check that DSP STATUS is GOOD.

**5** This step checks ECG leads gain.

a. Connect the leads front end cable to the patient simulator.

b. Apply a 1 mV sine wave at 1–10 Hz to the ECG Input connector.

c. Select the appropriate leads. Most simulators have a 1mV output. However, not all leads on the simulator output 1mV. Check the simulator user's manual to determine which lead provides a 1mV output, then select the correct lead on the test screen for making measurements.

d. The screen continually updates test values shown for PEAK TO PEAK. Check that these displayed values, both MONITOR and DIAGNOSTIC, are 1000 ±10%.

**6** This step checks ECG paddles gain:

a. Connect the paddles cable to the patient simulator.

b. Apply a 1 mV sine wave at 1–10 Hz to the ECG Input connector.

c. Select PADDLES at the defibrillator.

d. The screen continually updates test values shown for PEAK TO PEAK. Check that these displayed values, MONITOR is 1000 ±10%. Diagnostic bandwidth is not used for paddles ECG.

**7** This step checks ECG noise with the paddles front end.

a.Choose PADDLES as SELECTED LEAD.

b.Short the ECG paddles together and read PEAK TO PEAK value, MONITOR bandwidth. Noise should be ≤40µV.

**8** This step checks ECG noise with the leads front end.

a.Connect the leads cable to an AAMI patient termination.

b.Choose LEAD I as the SELECTED LEAD.

c.Read PEAK TO PEAK values for DIAGNOSTIC and MONITOR bandwidth. The noise value for monitor bandwidth should be ≤40µV. The noise value for diagnostic bandwidth should be ≤40µV.

d.Repeat steps a, b, and c to measure the lead noise level for each lead.

**NOTE**

Noise is specified in this manual using an AAMI patient termination. If an AAMI patient termination is not available, noise can generally be measured using the ECG simulator, with simulator power turned off. However, some simulators have an output impedance which can cause erroneous results when measuring ECG noise.

## PCI Calibration

PCI calibration should be performed whenever setup is lost or whenever the user suspects that PCI indication is wrong. Perform the following steps to calibrate PCI.

**1** Attach the paddle set to the defibrillator.

**2** Access the setup/diagnostic menu.

**3** Select TEST ECG in the setup/diagnostic menu.

**4** Press (Sync) and (HR Alarm) simultaneously, so that OFF appears to the right of the PCI value.

**5** While shorting the paddles together, press (Sync) and (HR Alarm) simultaneously. The PCI value should now indicate 0±2 Ω and ON should now appear next to the PCI value.

**NOTE**

Turning the PCI indicator off, then on again calibrates it to 0 Ω. If you do not short the paddles together, you will lose the PCI indicator calibration.

**6** Replace paddles in pockets. The PCI value with the paddles in the pockets should be between 20 and 100 Ω (the PCI value varies because of inductance in the circuit).

## Auxiliary Function Tests—CRT Test

This test lets you check the operation and alignment of the CRT.

### Test Prerequisites

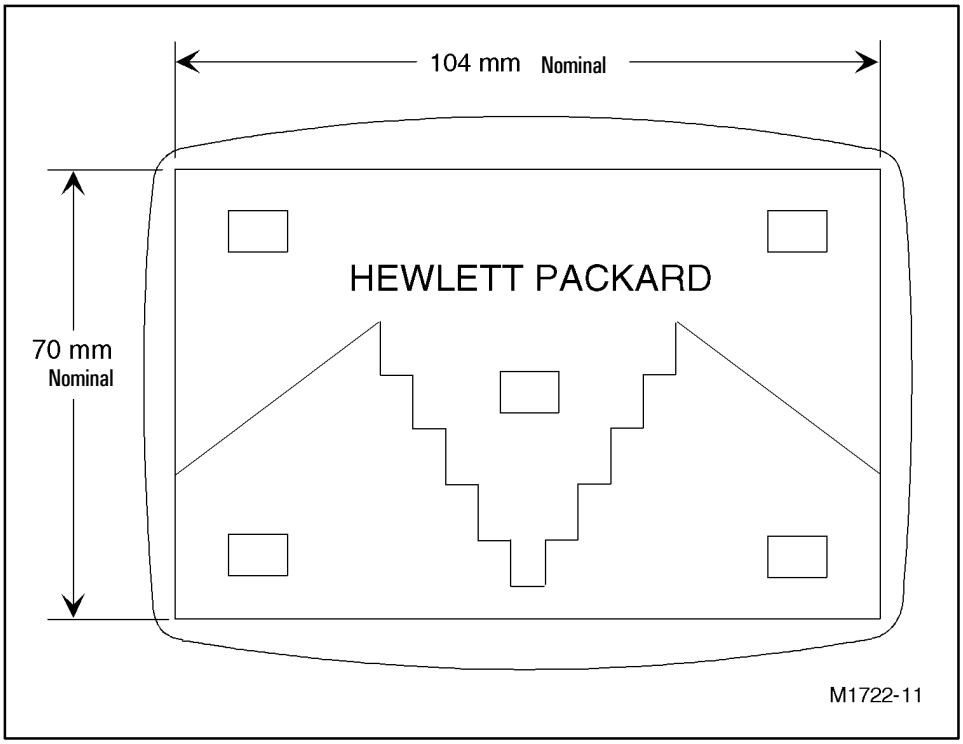
A ruler that measures in millimeters is required to measure the display size.

### Testing the CRT

To perform the CRT test, follow these steps:

**1** Select TEST CRT in the setup/diagnostic menu; the display shows the information shown in Figure 3-5.

**Figure 3-5**




**CRT Test: Test Pattern**

**2** To determine whether the defibrillator CRT meets specifications, observe the test pattern to ensure:

- Accurate rendition of all lines
- No random lines or dots in the display

**3** Check that the height and width of the display is within the limits shown in Figure 3-5.

**4** Check that all lines and characters are in focus.

**5** Check that the display is centered on the CRT face, vertically and horizontally.

**6** Check that the display is aligned horizontally and vertically.

**7** Check that the intensity of the displayed image is acceptable.

## Auxiliary Function Tests—Recorder Test

The recorder test checks recorder parameters, and prints a test pattern to check the printhead and paper drive mechanism.

### Test Prerequisites

Recorder paper, and a ruler that measures in millimeters.

### Testing the Recorder

To run the recorder test, follow these steps:

**1** Check that the recorder contains paper.

**2** Highlight `TEST RECORDER` on the main setup/diagnostic menu.

**3** Press (Record) or (Lead Select) . The recorder starts printing a series of test patterns.

**4** When the printed strip is about 3 feet long, press (Record) or (ECG Size) to stop the printing and return to the setup/diagnostic menu. Figure 3-6 shows the ECG areas of the test pattern.

Inspect the recorder strip for:

• Consistent print quality for all pattern areas

• Constant width for all pattern areas

• Straight diagonal lines

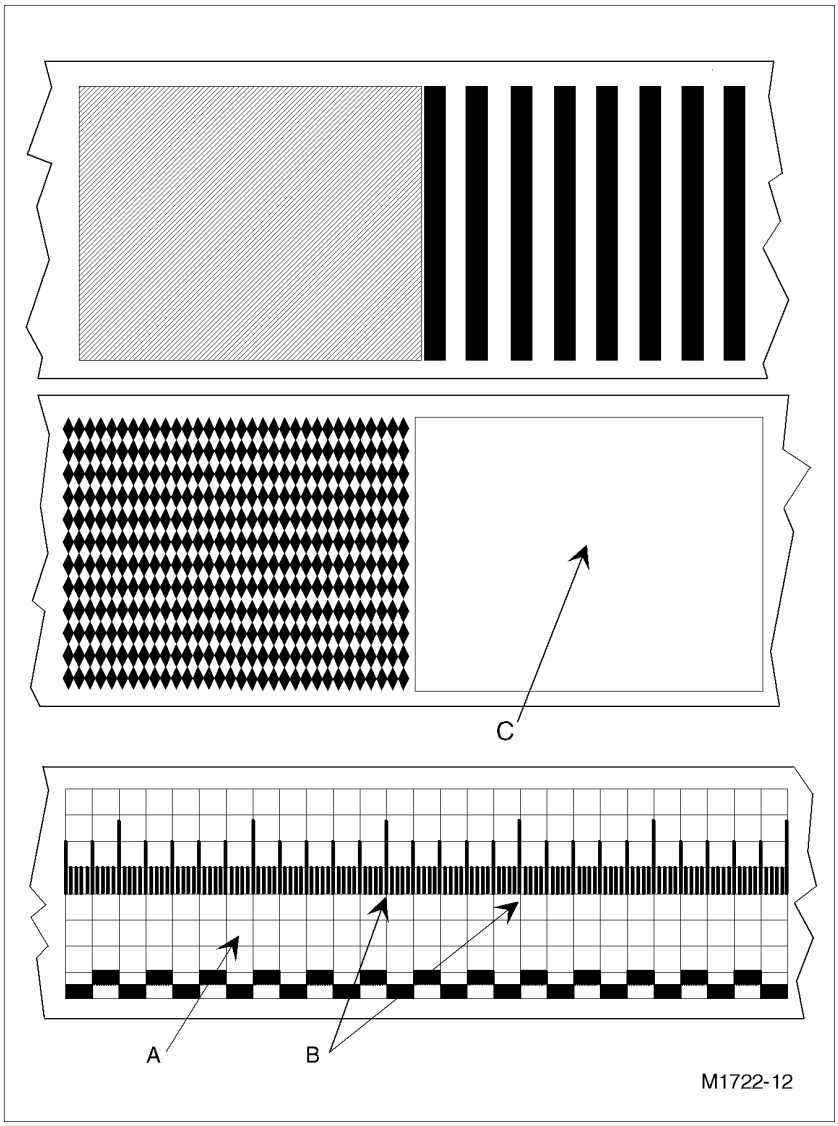
• Visible separation between the close parallel lines

• Clean black bars with no dropout in black areas

• Accurate rendition of all characters

- A distance of 25 mm ±2 mm between the longest tick marks (5 mm between the intermediate tick marks)

**Figure 3-6**




**Recorder Test: Test Pattern**

A. Test pattern for checking print speed.

B. Major tick marks.

C. Test pattern printout of all characters and symbols.

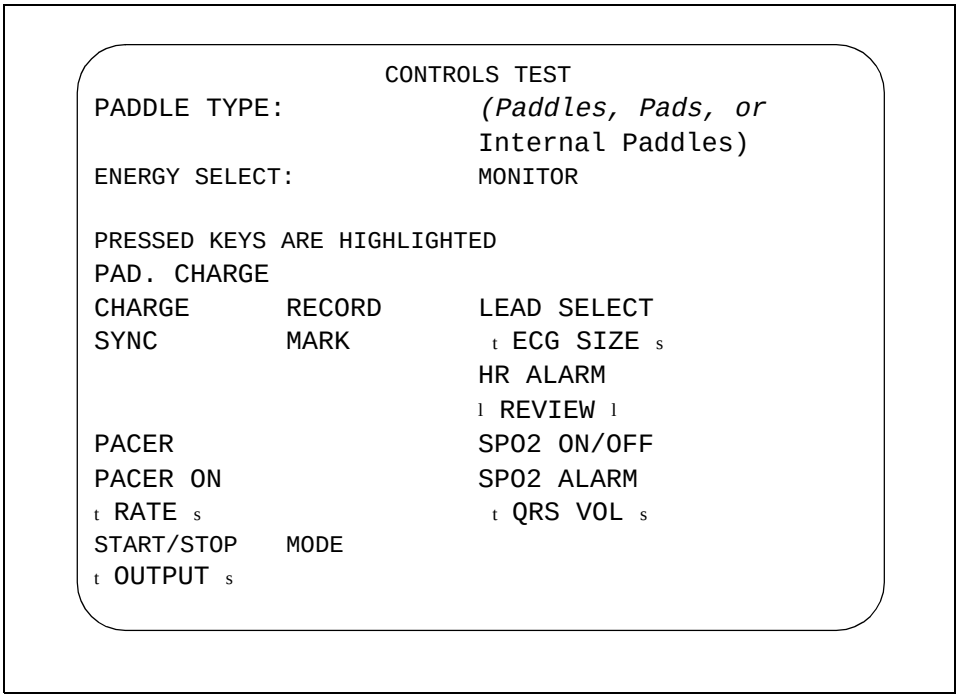
## Auxiliary Function Tests—Controls Test

This test checks the operation of the panel keys.

To test the panel key operation, follow these steps:

**1** Select TEST CONTROLS in the setup/diagnostic menu. The information shown in Figure 3-7 is displayed.

**Figure 3-7**




**Controls Test**

**2** Check that the entry for PADDLE TYPE matches the type that is attached (paddles, pads, or internal paddles).

If you disconnect the paddles cable, the entry changes to NONE.

**3** Turn the Energy Select control to each energy level position, checking that the entry for Energy Select on the display matches the current control position.

**4** Under PRESSED KEYS ARE HIGHLIGHTED, press each key listed. Simultaneously, check that the key name in the display is highlighted while the key is depressed. Highlighting indicates that the defibrillator has detected the key press. See Table 3-4 for a list of keys and the response you should see on the monitor display.

**Table 3-4** **Controls Test Steps**

| Key | Key Press | Response on Display |
|---|---|---|
| Paddles Charge | Press the Charge button on the side of the right external paddle. | PADDLES, PADS, or INTER-NAL PADDLES is highlighted. |
| Charge | Press the panel Charge key. | CHARGE is highlighted. |
| Sync | Press the panel Sync key. | SYNC is highlighted. |
| Record | Press the panel Record key. | RECORD is highlighted. |
| Mark | Press the panel Mark key. | MARK is highlighted. |
| Lead Select | Press the panel Lead Select key. | LEAD SELECT is highlighted. |
| ▼ ECG Size ▲ | Press the panel ▼ ECG Size key. | The ▼ arrow is highlighted. |
| | Press the panel ECG Size ▲ key. | The ▲ arrow is highlighted. |
| HR Alarm | Press the panel HR Alarm key. | HR ALARM is highlighted. |
| ● Review ● | Press the ● Review key. | The left ● is highlighted. |
| | Press the panel Review ● key. | The right ● is highlighted. |
| Pacer On | Press the Pacer On key. | PACER ON is highlighted. |
| ▼ Rate ▲ | Press the panel s Rate key. | The ▼ arrow is highlighted. |
| | Press the panel Rate ▲ key. | The ▲ is highlighted. |
| Start/Stop | Press the panel Start/Stop key. | START/STOP is highlighted. |
| ▼ Output ▲ | Press the panel ▼ Output key. | The ▼ arrow is highlighted. |
| | Press the panel Output ▲ key. | The ▲ arrow is highlighted. |
| Mode | Press the panel Mode key. | MODE is highlighted. |
| $SpO_2$ On/Off | Press the panel $SpO_2$ On/Off key. | SPO2 ON/OFF is highlighted. |
| $SpO_2$ Alarm | Press the panel $SpO_2$ Alarm key. | SPO2 ALARM is highlighted. |
| ▼ QRS 🔊 ▲ | Press the panel ▼ QRS 🔊 key. | The left ▼ arrow is highlighted. |
| | Press the panel QRS 🔊 ▲ key. | The left ▲ arrow is highlighted. |

## Auxiliary Function Tests—Indicator Test

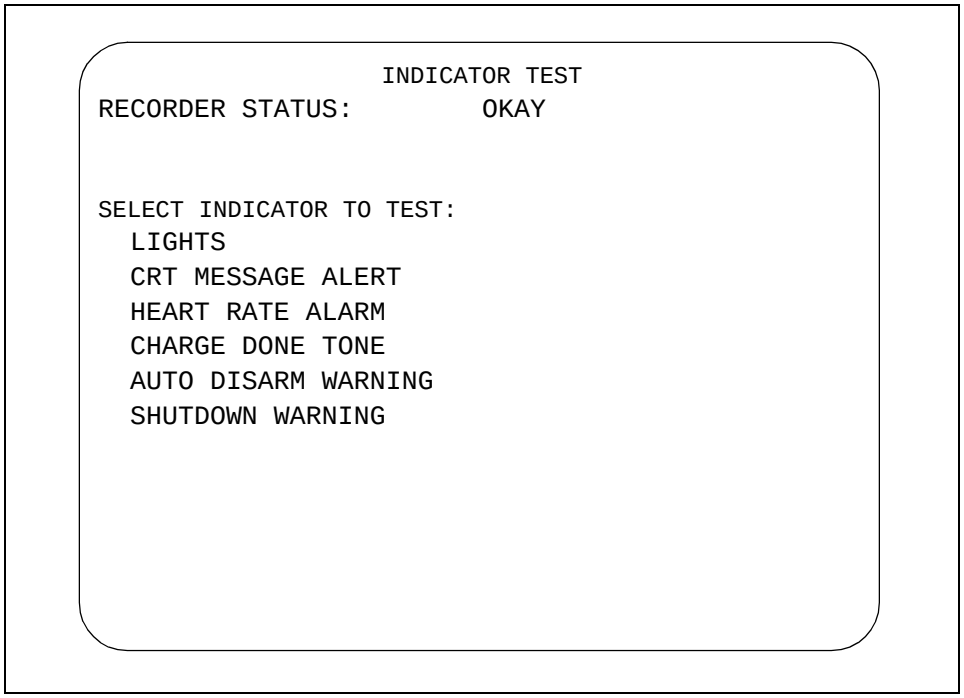
The indicator test exercises each LED and audio tone controlled by the defibrillator.

### Testing the Indicators

To test the defibrillator indicators, follow these steps:

**1** Select `TEST INDICATORS` on the setup/diagnostic menu; the defibrillator displays the information in Table 3-8.

**Figure 3-8**




**Indicators Test**

**2** Check that the entry for `RECORDER STATUS` is `OKAY`. (If the recorder is out of paper, the entry is `CHECK`.)

**3** The items under `SELECT INDICATOR TO TEST` are tests for the lights and audible tones. Use the (▼ECG Size▲) and (Lead Select) keys to select and start a test. To stop one of these tests, press (Lead Select) again. Each test is described, next.

`LIGHTS` — Sequentially lights the (Sync), the key panel (CHARGE DONE), the pacer (Pacer On), and the paddle (CHARGE DONE) indicators for about one second, each. If the unit has PCI indicators, they are lit while the `LIGHTS` test is running.

| | |
|---|---|
| CRT MESSAGE ALERT | Generates the CRT alert tone: three short tones; after a pause, the tones repeat. |
| HEART RATE ALARM | Generates a continuous tone. |
| CHARGE DONE TONE | Generates a continuous tone; this tone is lower in frequency than the heart rate alarm tone. |
| AUTO DISARM WARNING | Generates an intermittent tone that is the same frequency as the charge done tone. |
| SHUTDOWN WARNING | Outputs a tone that alternates continuously between the charge done tone and the heart rate alarm tone frequencies. |

## Auxiliary Function Tests—12-Lead Test

The 12-Lead test checks the 12-Lead, the DB-9 connector, the external modem and modem self tests.

### Test Prerequisites

Recorder paper.

### Testing the 12-Lead

To run the 12-Lead test, follow these steps:

**1** Check that the recorder contains paper.

**2** Highlight TEST 12-LEAD on the main setup/diagnostic menu.

**3** Press (Lead Select) . The setup/diagnostic menu displays the message “12-Lead Test. See 12-Lead Display Above.”

**4** The 12-Lead LED displays the message “Place a plug on the DB-9 connector.” Attach component part M1770-87909 to the DB-9 connector and press the space bar to continue.

**5** The 12-Lead LED displays the message “Connect the external modem.” Press the space bar to continue.

**6** The 12-Lead LED displays a series of modem self test messages.

**7** The defibrillator prints out a recorder strip with 12-Lead test results. Inspect the recorder strip to verify all test results are OK.

**8** The 12-Lead LED displays the message “Attach the 12-Lead ECG cable to take a 12-Lead or turn unit off to exit diagnostic test.” Turn the unit off to exit the diagnostic test.

## Pacer Test

This test verifies the pacer output level

Testing the pacer does not check the energy level that pacing delivers; testing verifies that the current delivered is equivalent to the levels indicated on the defibrillator screen.

To verify pacer operation, use a commercially available pacer tester. See Table 3-5 for TEST equipment information. Follow the instructions provided with the pacer tester to perform the test. Refer to Chapter 1, Table 1-5 for pacer specifications.

### Test Prerequisites

A test load (HP M1781A) is required.

### Testing the Pacer

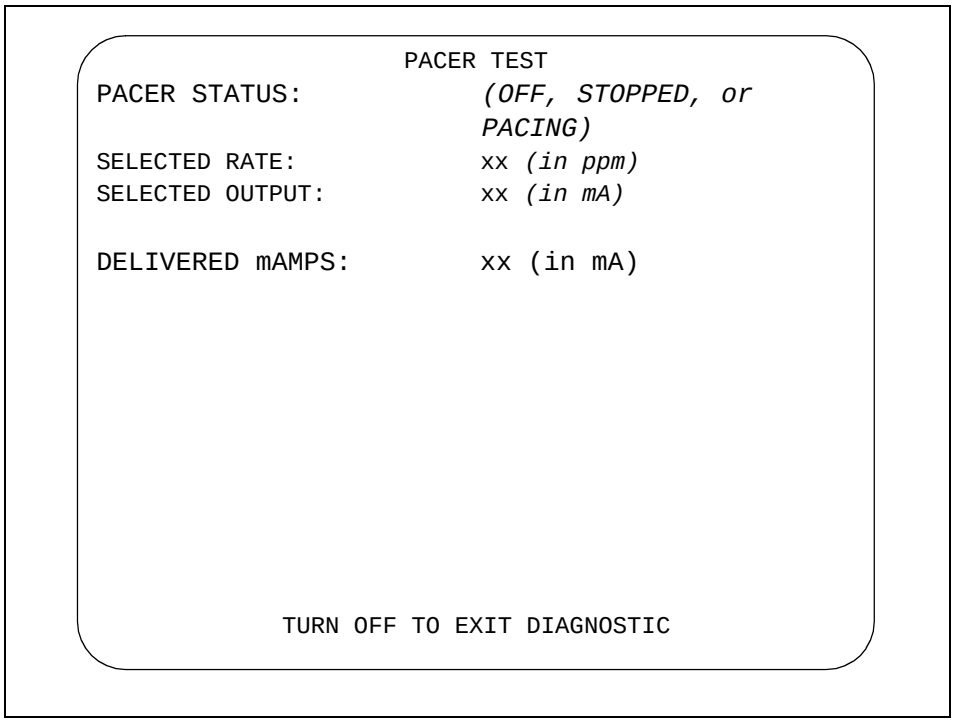
Follow these steps to perform the pacer test:

**1** Press the HR Alarm and Sync keys, while turning the Energy Select control from the **Off (Standby)** position to **Monitor On**. The setup/ diagnostic menu appears after a moment.

**2** Select TEST PACER on the setup/diagnostic menu.

**3** Press Lead Select to select the Pacer test. The monitor displays the information shown in Figure 3-9.

**Figure 3-9**


PACER TEST
PACER STATUS: (OFF, STOPPED, or PACING)
SELECTED RATE: xx (in ppm)
SELECTED OUTPUT: xx (in mA)
DELIVERED mAMPS: xx (in mA)
TURN OFF TO EXIT DIAGNOSTIC

**Pacer Test**

| | |
|---|---|
| PACER STATUS | Shows whether the pacer function is turned off, is turned on but is not pacing (STOPPED), or is pacing (PACING). The (Pacer On) key turns the pacing function on and off; pacing can be turned on and also be stopped. (PACER STATUS may also show NO PADS or PADS OFF momentarily after START is pressed.) |
| SELECTED RATE | Indicates the current output rate, in pulses per minute, as selected by the pacer (▼ Rate ▲) key. |
| SELECTED OUTPUT | Shows the current output level, in mA, as selected using the pacer (▼ Output ▲) key. |
| DELIVERED mAMPS | Indicates the output level of the delivered pulses as measured by the defibrillator, in mA. |

**4** Connect the test load (HP M1781A).

**5** Press (Pacer On) once, to turn on the pacer function. The indicator in the key should turn on; PACER STATUS should say STOPPED.

**6** Press (▼ Output ▲) to increment the pulse output to the desired level. The current level is displayed on the screen.

**7** Press (Start/Stop) to start pacing. PACER STATUS should say PACING.

**8** Check that the DELIVERED mAMPS on the display is within these specifications:

| Output Level | DELIVERED mAMPS |
|---|---|
| ≤50 mA: | ±5 mA |
| > 50mA: | ±10% |

## Shock Advisory Test

Connect an ECG code simulator to the adapter cable M2472A in order to acquire the ECG and defibrillate to the internal load of the simulator. (Symbio CS300, Dynatech 3000/4000 or equivalent).

### Testing the Shock Advisory

To run the shock advisory test, follow these steps:

**1** Apply normal ECG. Press (Record) . Press (Analyze) . The ECG strip will print out “Analyzing.” After a few seconds “No Shock Advised” will be printed.

**2** Simulate Systole. Run a baseline to have no shockable event. The ECG strip will print out “Analyzing.” After a few seconds “No Shock Advised” will be printed.

**3** Apply VF (Ventricular Fibrillation) rhythm. Press (Record) . Press (Analyze) . The ECG strip will print out “Analyzing.” After a few seconds “Shock Advised” will be printed, followed by the printed value of the pre-selected energy level. Discharge by pushing both buttons on the pads connectors in order to print out the delivered energy.

**4** Print out the Event Summary report.

**5** Reconfigure the defibrillator with the original customer setup.

## Parameter Function Tests—$SpO_2$ Test

Testing of $SpO_2$ includes an internal self-test and a functional test.

### $SpO_2$ Internal Self-Test

Every time the $SpO_2$ monitoring is turned on, the unit runs a self-test on the $SpO_2$ option board.

**1** Turn the defibrillator on by turning the Energy Select control to **Monitor On**.

**2** Press the $SpO_2$ On/Off button to turn $SpO_2$ monitoring on.

**3** Verify that no error messages appear on the display.

**4** Press the $SpO_2$ On/Off button to turn $SpO_2$ monitoring off.

### $SpO_2$ Functional Test

**1** Attach an $SpO_2$ sensor to a normal, healthy person. Refer to the sensor packaging for directions on how to attach the sensor.

**2** Plug the sensor into the defibrillator. If you are not using a Hewlett-Packard sensor, you must use the M1900B adaptor cable.

**3** Turn the Energy Select control to **Monitor On**.

**4** Press the $SpO_2$ On/Off button.

**5** After 15 seconds, verify that the display shows an $SpO_2$ reading and a pulse rate.

**6** Verify that the Pulse Amplitude Indicator moves up and down.

**7** Verify that the $SpO_2$ reading is between 95% and 100%. If the $SpO_2$ reading is much below 95% and the person is healthy, the reading indicates a monitor or sensor error.

**8** Press the $SpO_2$ On/Off button to turn $SpO_2$ monitoring off.

## Parameter Function Tests—HR Alarm Test

To test the HR Alarm an ECG simulator is needed.

**1** Run a normal ECG at 60 Hz

**2** Press (HR Alarm), verify alarm setting in upper right corner of the display

**3** Change the ECG simulator to get beyond both the upper and lower HR Alarm limits.

**4** After a few seconds (approximately six seconds) the recorder will print a report and the alarm will sound.

## Parameter Function Tests—ECG Simulation

Taking an ECG using a 12-lead ECG simulator lets you verify areas of operation that the setup/diagnostic menu tests cannot test:

• The integrity of the leadwires

• The accuracy of the gain settings

To simulate an ECG, use a commercially available ECG simulator. Follow the testing instructions provided with the simulator.

## Parameter Function Tests—Sync Cardioversion Test with Internal Monitor

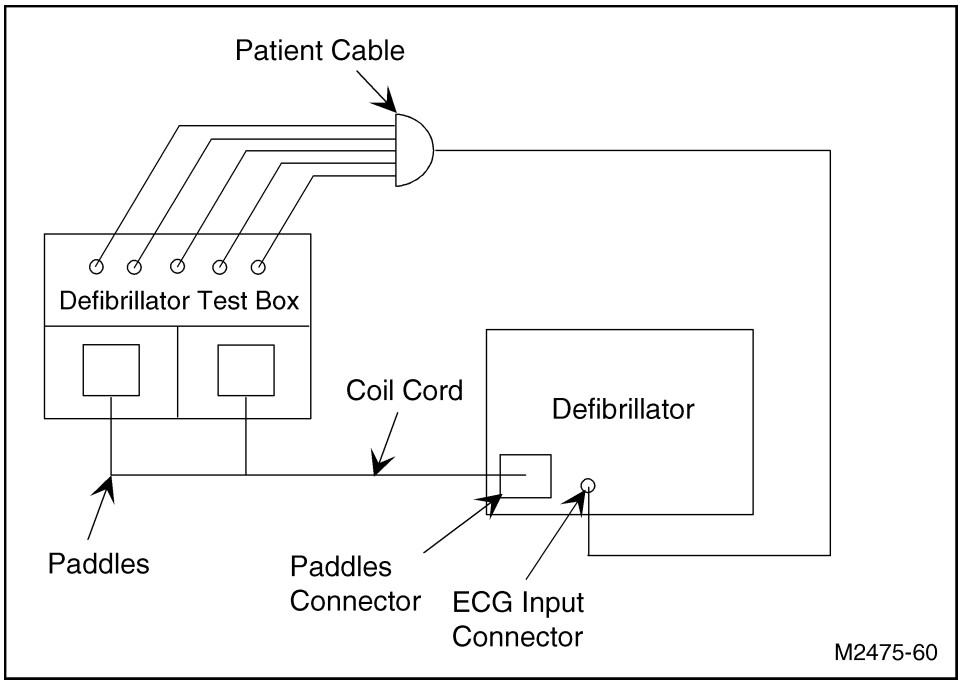
This test verifies the unit's internal delay for sync cardioversion.

To test sync cardioversion with the unit's internal monitor, follow this procedure:

**1** Use a defibrillator test box capable of measuring synchronized cardioversion delay time.

**2** Connect a patient cable between the defibrillator test box and the defibrillator ECG In connector. See Figure 3-10.

**Figure 3-10**




**Sync Cardioversion Test Setup, Internal Monitor**

**3** On the defibrillator, select LEAD II as the ECG source.

**4** Put the defibrillator test box into cardioversion test mode.

**5** Press (Sync) on the defibrillator to put the unit in sync mode. The ECG signal should have synchronization markers highlighting the ECG trace. Adjust ECG SIZE, if necessary.

**6** Turn the Energy Select control on the defibrillator to 50 joules.

**7** Place the paddles on the defibrillator test box paddle pads; press the charge button on the apex paddle. Wait for the Charge Done indicators on the defibrillator.

**8** Press and hold both shock buttons on the paddles until the defibrillator discharges.

**9** Verify that the measured cardioversion delay time is less than 60 ms. If not, refer to Table 4-8 in Chapter 4, *Troubleshooting.*

## Parameter Function Tests—Sync Cardioversion Test with External Monitor

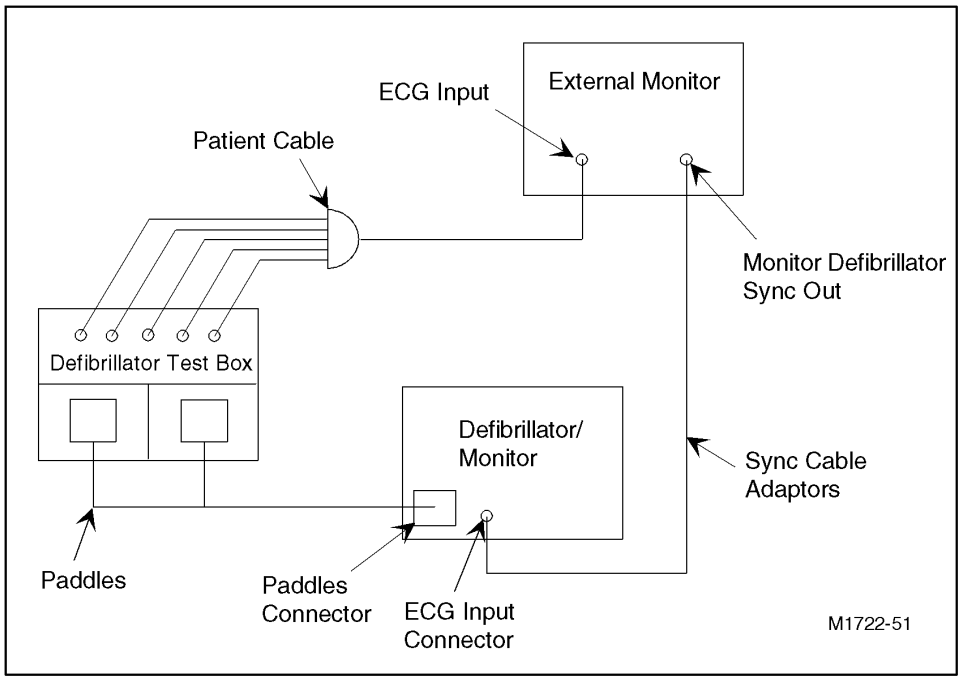
The sync cardioversion test should be performed only if the defibrillator is used with an external monitor as the synchronizing source. Using an external monitor as the synchronizing source adds some amount of delay between the patient R-wave and defibrillator discharge. This test verifies that the total delay is within acceptable limits.

To test sync cardioversion with an external monitor, follow this procedure:

**1** Use a defibrillator test box capable of measuring synchronized cardioversion delay time.

**2** Connect a patient cable between the defibrillator test box and the external monitor. See Figure 3-11.

**Figure 3-11**




**Sync Cardioversion Test Setup, External Monitor**

**3** Connect the sync interface cable between the external monitor's DEFIB/SYNC output and the defibrillator ECG In connector.

**4** Set up the external monitor to monitor LEAD II.

**5** On the defibrillator, select LEAD II as the ECG source.

**6** Put the defibrillator test box into cardioversion test mode.

**7** Press (Sync) on the defibrillator to put the unit in sync mode. The ECG signal should have synchronization markers highlighting the ECG trace. Adjust ECG SIZE, if necessary.

**8** Turn the Energy Select control on the defibrillator to 50 joules.

**9** Place the paddles on the defibrillator test box paddle pads; press the charge button on the apex paddle. Wait for the Charge Done indicators on the defibrillator.

**10** Press and hold both shock buttons on the paddles until the defibrillator discharges.

**11** Verify that the measured cardioversion delay time is less than 60 ms. If it doesn't, don't use the external monitor/defibrillator for synchronized cardioversion.

## Safety Tests

The following safety tests are performed at the time of manufacture to assure compliance with these standards: IEC 601-1, IEC 601-2-4, IEC 601-2-25, UL 2601, and CSA 22.2 No. 601.1.

- Chassis-to-ground resistance within an expected range of ≤ 200 mΩ
- Ground wire leakage current (Normal Condition) within an expected range of ≤ 500 uA
- Ground wire leakage current (Single Fault Condition) within an expected range of ≤ 1000 uA
- Patient Lead Leakage Current Source (Normal Condition) within an expected range of ≤ 10 uA/100 uA for CF/BF Applied Parts
- Patient Lead Leakage Current Source (Single Fault Condition) within an expected range of ≤ 50 uA/5000 uA for CF/BF Applied Parts
- Patient Lead Leakage Current With Mains on applied part (Normal Condition) within an expected range of ≤ 10 uA/100 uA for CF/BF Applied Parts
- Patient Lead Leakage Current With Mains on applied part (Single Fault Condition) within an expected range of ≤ 50 uA/5000 uA for CF/BF Applied Parts
- Patient Lead Leakage Current Auxiliary (Normal Condition) within an expected range of ≤ 10 uA/100 uA for CF/BF Applied Parts
- Patient Lead Leakage Current Auxiliary (Single Fault Condition) within an expected range of ≤ 50 uA/500 uA for CF/BF Applied Parts

Note: All leakage current tests are Normal and Reverse Polarity Conditions.

These tests should be part of your preventive maintenance program, and should be performed after any corrective maintenance to assure continued compliance with the named standards.

To perform these tests, use commercially available safety testers or analyzers designed specifically for this purpose. Follow the manufacturer's operating instructions for hookup and test procedures.

# Preventive Maintenance

Preventive maintenance for the defibrillator is a superset of performance verification and consists of the battery capacity test, printing the system error log, cleaning and inspection, followed by routine maintenance and/or troubleshooting.

**CAUTION**

The defibrillator does not require any kind of lubrication. Lubricating any part of the defibrillator could damage it or diminish its performance.

## Battery Capacity Test

The battery capacity test should be performed after any of the following events:

- After putting a new battery in service.
- After 90 days of service (more often if defibrillator use frequently depletes the battery without allowing time for full charge cycles).
- After the defibrillator has been stored for more than 30 days.

The battery capacity test should be performed with the battery support system.

See the *HP CodeMaster 100 Portable Defibrillator/Monitor User's Guide* for detailed information on performing this test.

Batteries should be replaced after two years of service.

## Battery Evaluation

The HP M2476B and M2477B NiCd batteries are used to power the HP CodeMaster 100 Defibrillator/Monitor with Integrated 12-Lead ECG Option. Proper evaluation and care procedures ensures that these batteries have the energy required to operate the defibrillator and deliver the appropriate therapy. For information on the HP M2476B and HP M2477B battery support systems, battery evaluation aids, and evaluation and care procedures, refer to the *HP M2476B & M2477B Battery Evaluation and Care User's Guide* (M2475-92100).

## Printing the System (Error) Log

When an error occurs during normal operation, an error code associated with the error is stored in memory in the error log. Selecting `PRINT LOG` in the setup/diagnostic menu prints the stored error log. To decipher an error code on the printout, refer to the error lists in Chapter 4, *Troubleshooting*. Store the error log printout with the defibrillator's permanent maintenance record.

As part of preventive maintenance, HP recommends you clean the printer after printing the system log.

When the printout is complete, you can select another test from the setup/diagnostic menu.

## Care and Cleaning

The defibrillator and its accessories are chemically resistant to common cleaning solutions and non-caustic detergents. The following list includes some approved cleaning solutions.

- 90% Isopropyl alcohol (except adapters and patient cable)
- Soap and water
- Chlorine bleach (30ml/l water)

**NOTE**

Keep the outside of the unit clean and free of dust and dirt. Clean the paddles thoroughly to prevent build-up of dried electrolyte paste.

**CAUTION**

Do not allow any fluids to penetrate the unit case. Avoid pouring fluid on the unit while cleaning.

Do not use abrasive cleaners, or strong solvents such as acetone, or acetone-based compounds.

Clean the display screen carefully. It is especially sensitive to rough handling and is subject to scratching.

Do not steam-sterilize the monitoring leads, submerge them for prolonged periods, or heat them above 50°C. If metallic surfaces become oxidized, clean them with a very light abrasive (toothpaste). Do not use highly abrasive cleaners, such as steel wool or silver polish.

Do not steam- or gas-sterilize the external paddle set or the external pads.

See the *HP CodeMaster 100 Portable Defibrillator/Monitor User's Guide with Integrated 12-Lead ECG Option* for detailed information on cleaning and sterilizing the internal paddles.

# Test Equipment

## Commercial Test Boxes and Simulators

Table 3-5 lists specifications for commercially available test boxes and simulators used when performing certain performance verification tests. In addition, a test load is available for testing the external pads adapter (HP M1781A). Test equipment is called out within each test procedure when needed.

**Table 3-5** **Equipment List**

| Equipment/Test | Specifications |
|---|---|
| **Calibrated Leads ECG simulator** (ECG simulation test) | ±2% accuracy |
| **Calibrated Paddles ECG simulator** (ECG simulation test) | ±2% accuracy |
| **AAMI patient termination** (ECG simulation test) | 47 nF in parallel with 51 K Ω together in series with each lead wire |
| **Defibrillator test box** | |
| (Delivered energy level test) | |
| Load resistance: | 50 Ω ±1% (non-inductive) |
| Measurement range | |
| Maximum energy: | ≥450 joules |
| Maximum voltage: | ≥6000 V |
| Maximum current: | ≥120 A |
| Measurement accuracy | |
| ≥20 joules: | ≤±2% of reading (damped sinusoidal waveform) |
| < 20 joules: | ≤±0.4 joules (damped sinusoidal waveform) |
| Cardioversion measurement range: | –150 to +150 ms |
| **Pacer tester** | |
| Load impedance: | ≤400 Ω |
| Current measurement accuracy | |
| 30 mA–50 mA: | < ±2 mA |
| 50 mA–200 mA: | < ±4% |
| Rate measurement accuracy | |
| 40–180 ppm: | < ±0.5% |
| Waveform duration accuracy: | ±1ms |

# Performance Verification Checklist

Model number _____
Serial number _____
Test date _____
Test technician _____

## Visual Inspection

Disconnect the defibrillator and inspect for the following:

- Loose or missing hardware.
- Frayed or damaged wiring.
- Mechanical damage.
- Evidence of liquid spill.
- Dirt on the thermal printhead
- Recorder roller wear.
- Wear or damage to power cord and associated strain relief.
- Corroded or damaged electrodes.
- Damaged adaptors or patient cables.
- Dirt on the thermal printhead.
- Verify that the (Charge) and (Sync) indicators light momentarily, when you turn the Energy Select control to **Monitor On** to turn on the defibrillator.

Enter the data to record in the format V:x, where x is p (pass) or f (fail).
For example: V:p. _____

## Power On Self Test

- Power on the unit

Enter the data to record in the format PO:x, where x is p (pass) or f (fail).
For example: PO:p. _____

## Calibration Test

- Calibrate Defibrillator

Enter the data to record in the format C:x, where x is p (pass) or f (fail).
For example: C:p. _____

## Defibrillator Test

(Conduct these tests in setup/diagnostic mode)

Using only battery power, set Energy Select to 100; test the following:

- Msec. to charge—aaaa
- Delivered Energy—bbb
- Impedance—cc
- Peak Current—dd

Using only battery power, set Energy Select to 360; test the following:

- MSec. to charge—eeee
- Delivered Energy—fff
- Impedance—gg
- Peak Current—hh

- Disarm Test—m

Enter the data to record in the format DT:aaaa,bbb,cc,dd,eeee,fff,gg,hh,m.
For example: DT:1300,100,50,30,3600,360,50,55,p.

## ECG Tests

- o Leads Status, Paddle Status, and DSP Status—x
- o DC Offset—aaa
- o ECG Leads gain (Diagnostic)—bbbb
- o ECG Leads gain (Monitor)—cccc
- o ECG Paddles gain (Monitor)—dddd
- o PCI Calibration
    - o paddles shorted—e
    - o paddles in pocket—fff

Enter the data to record in the format E:x,aaa,bbbb,cccc,dddd,e,fff. For example: E:p,0,800,800,800,1,60. _____

## Auxiliary Function Tests

- o CRT Test
- o Recorder Test
- o Controls Test
- o Indicator Test
- o 12-Lead

Enter the data to record in the format A:x, where x is p (pass) or f (fail).
For example: A:p. _____

## Shock Advisory Test

- o Apply normal ECG
- o Simulate Systole
- o Apply VF

Enter the data to record in the format A:x, where x is p (pass) or f (fail).
For example: SA:p. _____

## Pacer

- o Pacer Test
    - o Selected Output set to 40mA—aa
    - o Selected Output set to 100mA—bbb

Enter the data to record in the format PT:aa,bbb. For example: PT:40,99.

## Parameter Function Tests

- $SpO_2$Test (Option)
- HR Alarm Test
- ECG Simulation Test
- Sync Cardioversion Test
  cardioversion delay time is less than 60ms

Enter the data to record in the format F:x, where x is p (pass) or f (fail).
For example: F:p.

## Safety Tests

Indicate Test conditions as follows:

- External Pads, Paddles/Internal Paddles—aa
- Chassis-to-Ground Resistance (Mains voltage applied)—bbb
- Ground wire Leakage Current (Normal condition)—ccc
- Ground wire Leakage Current (Single Fault)—dddd
- Patient Lead Leakage Current Test
  - o Source (Normal Condition)—eee
  - o Source (Single Fault Condition)—ffff
  - o With Mains on applied part (Normal Condition)—ggg
  - o With Mains on applied part (Single Fault Condition)—hhhh
  - o Auxiliary (Normal Condition)—iii
  - o Auxiliary (Single Fault Condition)—jjj

Note: All leakage current test are Normal and Reverse Polarity Conditions

Enter the data to record in the format S:aa,bbb,ccc,dddd,eee,fff,gggg,hhh,iii;
for example:*S:BF,09,400,700,90,400,700,16,250*.

**Note**: When recording test results, separate tests by a semi-colon(;). For example: *Note: When recording test results, separate tests by a semi-colon(;). For example: V:p;PO:p;C:p;DT:1300,100,50,30,3600,360,50,55,p;E:p,0,800,800, 800,1,60;A:p;SA:p;PT:40,99;F:p;S:BF,09,400,700,90,400,700,16,250*

Print out the system (error) log. Store the printout with the defibrillator's permanent maintenance record.

Print out the setup menu settings. Store the printout with the defibrillator's permanent maintenance record.

## Comments:

# Troubleshooting

## Introduction

This chapter provides information for localizing defibrillator/monitor problems to the assembly level. This troubleshooting information is designed for use with the defibrillator's setup/diagnostic tests (see "Setup/Diagnostic Menu Tests" on page 3-7) to efficiently repair the defibrillator with a minimum of equipment.

### Maintenance Philosophy

Repair philosophy for the M2475B CodeMaster 100 Portable Defibrillator/Monitor with Integrated 12-Lead ECG is assembly replacement. Replaceable CodeMaster 100 assemblies are identified in Chapter 7, *Parts Lists*.

Repair philosophy for the M2480B Battery Support System, M2478A DC Power Module and M2479A AC Power Module is instrument replacement with customer returning the defective unit to Hewlett-Packard Company. Replaceable fuse and cable assemblies for these instruments are identified in Chapter 7.

**CAUTION**

Individual component replacement should not be attempted outside of an authorized HP repair facility. Component level repair is extremely difficult due to the extensive use of surface mount technology and the high parts-density on the circuit boards. Unauthorized component replacement can impair defibrillator performance.

### Troubleshooting Guide

The following information suggests ways of using the information in this manual to troubleshoot defibrillator failures.

#### Verify the Failure

Before troubleshooting the defibrillator, make sure that the failure is not the result of improper use. See the *HP CodeMaster 100 Portable Defibrillator/Monitor User's Guide* for a condensed description of controls and their use.

The built-in diagnostic tests are useful for verifying some failures.Refer to *Using Setup/Diagnostic Tests in Troubleshooting* which follows in this chapter, for a description of these tests.

### Check the Error (System) Log

Print the error log to see if it contains an error code. You can clear the error log, operate the defibrillator and repeat the failure, and then print the error log to see if the failure created a new error code. Refer to *The System Log* later in this chapter for detailed information on error codes.

### Using the Troubleshooting Tables

Check to see which functional areas of the defibrillator are affected. The troubleshooting tables organize symptoms by type: audible, displayed, and symptoms specific to a functional area of the defibrillator.

In the tables, find the symptoms that apply to the unit failure.

Try the solutions suggested in the tables for the symptoms of your defibrillator.

Before replacing parts, check that cables and connectors are seated, check that boards are seated and look for damaged parts.

In the tables, replace the first board listed, since the board most likely to fail is usually listed first. Verify that the failure still exists; then, replace the next board listed.

After repair, verify that the defibrillator operates to specification. See *Verification After Repair* later in this chapter for detailed information.

## Using Setup/Diagnostic Tests in Troubleshooting

The setup/diagnostic tests are built-in, menu-driven tests that can quickly check defibrillator operation without the use of additional equipment. The tests check these functional areas:

| | |
|---|---|
| **Defibrillator Test** | Checks defibrillator charging and verifies post shock data (Ipeak, delivered energy and patient impedance) |
| **ECG (monitor) Test** | Verifies monitor operation |
| **CRT Test** | Displays a test pattern |
| **Recorder Test** | Prints a test strip |
| **Controls Test** | Allows you to verify keypanel operation; on-screen indication gives direct feedback when a key is pressed |
| **Indicators Test** | Cycles the keypanel indicators so that you can verify LED operation; tests the CRT Alert tones. |

| | |
|---|---|
| **12-Lead Test** | Allows you to verify 12-Lead LED display, DB-9 connection, external modem operation and 12_Lead cable operation. |

Instructions for entering and using setup/diagnostic mode are found in Chapter 3, *Performance Verification and Maintenance.*

## Verification after Repair

After repairing the defibrillator, perform the tests described in Chapter 3, *Performance Verification and Maintenance* to verify operation of the defibrillator to specifications. In addition, perform the defibrillator calibration and the defibrillator test in the built-in menu tests.

## Test Equipment

The following test equipment is required to troubleshoot the defibrillator as described in this chapter. This equipment is all commercially available.

• A digital voltmeter such as the HP E2373A handheld multimeter.

• 12-Lead ECG simulator.

• Pacer tester.

• Energy meter.

• Paddles ECG simulator (built into many manufacturers energy meter).

## Test Tools

Two troubleshooting tools are provided to help diagnose instrument problems:

• patient cable test tool (M3710-80030)

• transmission test tool (M1770-87909, Rev. B)

## Patient Cable Test Tool (M3710-80030)

This tool is inserted into the outside left pouch of the carry bag. The carry bag is attached to the outside of the tWINs unit. This tool is used to test the integrity of the ECG patient cable.

## RS-232 Port Test Tool (M1770-87909, Rev. B)

This tool is used to test the RS-232 port on the Integrated 12-Lead Unit.

### Safety Considerations

**WARNING**

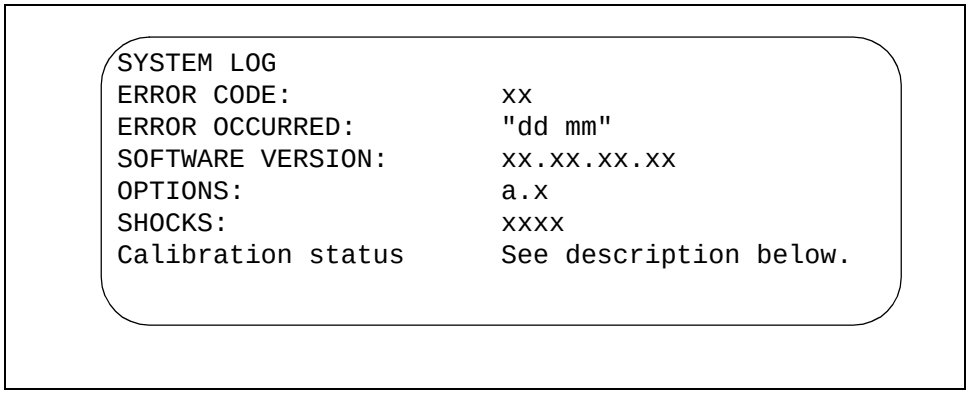
- **To remove power from the unit, you must turn the Energy Select control to *Off (Standby)*, and remove the battery.**
- **To disarm a charged unit, there are three methods:**
  1. **Turn the Energy Select control to the Off (Standby) position.**
  2. **Place the paddles in their holders on the defibrillator, and depress both shock buttons on the paddles.**
  3. **After 60 seconds, the unit automatically disarms.**
- **Before disassembling the unit, or removing or inserting any board or connector remove the battery.**
- **The defibrillator stores high voltage energy and is capable of delivering up to 360 joules of DC energy to a 50 ohm impedance.**

## The System Log

The system log is battery-maintained memory that stores error codes for the last error event that the unit detected. In addition, the system log contains software version and unit option information. The system log can be printed by entering the setup/diagnostic menu and selecting `PRINT LOG` as explained in Chapter 3, *Performance Verification and Maintenance*. See Figure 4-1.

As part of preventive maintenance, HP recommends that you clean the printer after printing the system log.

**Figure 4-1**




**System (Error) Log Format**

| | |
|---|---|
| ERROR CODE: | The error code of a run-time error. |
| ERROR OCCURRED: | The date and time that the error occurred according to the system clock. |
| SOFTWARE VERSION: | The software version of the firmware installed in the defibrillator; the version line has the following format:<br>`Monitor code revision.Reserved.DSP code revision.Defib code revision.` |
| OPTIONS: | A code in the form of: a.x<br>a = unit<br>x = internal pace pulse detection, 1 = enabled, 0 = disabled |
| SHOCKS: | The number of shocks since the shock counter was last reset. |
| Calibration status: | This area will contain one of these:<br>• `CALIBRATION PASSED` dd mmm yy—The last defibrillator calibration (on the date shown) was successful.<br>• `CALIBRATION FAILED` dd mmm yy —The last defibrillator calibration (on the date shown) failed; the defibrillator will still function but charge energy levels may not be accurate (the defibrillator will use a nominal value for the charge capacitor).<br>• `CALIBRATE DEFIB`—The defibrillator has not been calibrated or the calibration value has been lost. The defibrillator will still function but charge energy levels may not be accurate (the defibrillator will use a nominal value for the charge capacitor). |

## Error Codes

Table 4-1 describes the errors that can appear in the error log and suggests solutions. *Replace the board assemblies in the order shown; after replacing a board assembly, check to see if the problem has been resolved.* If the problem is still present, replace the next board assembly listed. When the unit is working properly, clear the error log. Refer to *Clearing the Error Log* later in this chapter for detailed information. If more than one defibrillator error occurs, the codes for those errors are summed and printed in hexadecimal form. The hexadecimal sum of any combination of these error codes yields a unique number. For example, an error code of 0AC can only be formed by the sum of error codes 080, 020, 008, and 004.

**Table 4-1 Error Codes**

| Error Code | Error Description | Possible Solution |
|---|---|---|
| 001 | The defibrillator capacitor charges at less than 6 joules/second. | 1 Replace high voltage charger board.<br>2 Replace control board.<br>3 Replace defibrillator capacitor. |
| 002 | The defibrillator capacitor charges to more than 120% of the desired voltage. | 1 Replace control board.<br>2 Replace high voltage charger board. |
| 004 | Unexpected drop in defibrillator capacitor voltage. | 1 Replace high voltage charger board.<br>2 Replace control board.<br>3 Replace defibrillator capacitor. |
| 008 | Unexpected voltage on defibrillator capacitor. | 1 Replace high voltage charger board.<br>2 Replace control board. |
| 010 | The safety relay has failed. | 1 Replace safety relay.<br>2 Replace high voltage charger board.<br>3 Replace control board. |
| 020 | The supply voltage is outside the nominal range. | 1 Replace DC supply board.<br>2 Replace control board. |
| 040 | A patient relay drive failure was detected. | 1 Check that relay control connector is plugged into high voltage board.<br>2 Check patient relay coil resistance. If outside nominal range, (3 Ω ±1 ohm) replace patient relay.<br>3 Replace high voltage charger board.<br>4 Replace control board. |
| 080 | A power-on failure has occurred. | Replace control board. |
| 100 | Defibrillator control firmware failure has occurred. | 1 Send error log and description of failure to the factory.<br>2 Cycle power. If problem persists, replace control board. |
| 400 | Patient relay drive redundancy failure. | Replace high voltage charger board. |
| ***Monitor Codes:*** | 1xxxx | For most monitor error codes, the cause is probably the control board. |

**Table 4-1** **Error Codes (Continued)**

| Error Code | Error Description | Possible Solution |
|---|---|---|
| 10001 | Monitor firmware failure has occurred. | 1 Send error log and description of failure to the factory.<br>2 Cycle power. If problem recurs, replace control board. |
| 10002 | Defibrillator timeout (does not return shock information). | 1 Send error log and description of failure to the factory.<br>2 Cycle power. If problem recurs, replace control board. |
| 10003 | Defibrillator timeout (does not accept configuration). | 1 Send error log and description of failure to the factory.<br>2 Cycle power. If problem recurs, replace control board. |
| 10004 | Defibrillator timeout (does not accept ECG data). | 1 Send error log and description of failure to the factory.<br>2 Cycle power. If problem recurs, replace control board. Replace ECG front end/pacer board. |
| 10005 | Clock timeout (Time-Out-Done clock is not ready). | Replace control board. |
| 10006 | Reserved. | |
| 10007 | Reserved. | |
| 10020 | Reserved. | |
| 10030 | Reserved. | |
| 10050 | Reserved. | |
| 10070 | Reserved. | |
| 10080 | Reserved. | |
| 100A0 | Reserved. | |
| ***Front End Codes:*** | 2xxxx | |
| 20001 | Sequential data error. | Cycle power. If problem recurs, replace ECG front end/pacer board. |
| 20002 | Total data error. | 1 Replace ECG front end/pacer board.<br>2 Replace control board. |
| 20003 | DSP timeout (Back-up Timer interrupt). | Replace control board. |
| 20004 | Front end hard failure. | Replace ECG front end/pacer board. |
| ***Pacer Codes:*** | 3xxxx | |

**Table 4-1** **Error Codes (Continued)**

| Error Code | Error Description | Possible Solution |
|---|---|---|
| 30001<br>30002<br>30003<br>30004<br>30005 | Pacer failure. | 1 Change pads and check pads adapter cable.<br>2 Restart the pacer.<br>If error reoccurs,<br>3 Replace ECG front end/pacer board.<br>4 Replace the control board. |
| ***Processor Codes:*** | 4xxxx | |
| 40001-40009 | Control board failure. | Replace control board. |
| ***$SpO_2$ Codes:*** | 5xxxx | |
| 50006 | The $SpO_2$ sensor is broken. | Attach new sensor and cable. |
| 50007 | $SpO_2$ data lost error. | Replace $SpO_2$ board. |
| 50008 | $SpO_2$ data lost error. | Replace $SpO_2$ board. |
| 50009 | Unable to communicate with the dual-port RAM. | 1 Cycle $SpO_2$ power.<br>2 Replace $SpO_2$ board. |
| 5000A | Hardware failure on the $SpO_2$ module. | 1 Cycle $SpO_2$ power.<br>2 Replace $SpO_2$ board. |
| 5000B | The $SpO_2$ module processing units cannot communicate. | 1 Cycle $SpO_2$ power.<br>2 Replace $SpO_2$ board. |
| 5000C | $SpO_2$ sensor fault. | Attach new sensor and cable. |
| 5000D | Software problem in the $SpO_2$ module. | 1 Cycle $SpO_2$ power.<br>2 Replace $SpO_2$ board. |
| 5000E | The monitor cannot communicate with the $SpO_2$ module. | 1 Cycle $SpO_2$ power.<br>2 Replace $SpO_2$ board. |
| | | 1 |
| ***Shock Advisory Codes:*** | 6xxxx | |
| 60001 | Shock advisory timeout failure. | Replace control board. |
| ***Internal Software Errors:*** | 0xxxx | |
| 07XXX | Internal software error. | 1 Replace control board.<br>2 Replace ECG System board. |
| 08XXX | Internal software error. | 1 Replace control board.<br>2 Replace ECG System board. |

If an error repeats, use the appropriate setup/diagnostic test to help locate the failure. The setup/diagnostic tests are described in Chapter 3, *Performance Verification and Maintenance*.

### Clearing the Error Log

After servicing the defibrillator/monitor, it is important to reset (clear) the error log. This process clears the entries for ‘‘Error Code" and ‘‘Error Occurred".

To clear the error code from the error log, follow these steps:

**1** Place the defibrillator in diagnostic mode.

**2** On the setup/diagnostic menu, move the highlight bar over `PRINT LOG`.

**3** Press the (Sync) and (HR Alarm) keys simultaneously.

Turn the Energy Select control to the **Off (Standby)** position to exit the setup/diagnostic menu.

# Troubleshooting Tables

The troubleshooting tables in this section help you to locate a fault and correct it. The following tables list errors and failure symptoms that can occur at power on, during normal operation, or as a result of setup/diagnostic tests. The tables define and explain the errors, and suggest one or more corrective actions for each.

The troubleshooting tables include the following:

Table 4-2 Describes tones made by the defibrillator.

Table 4-3 Explains system-level messages that the defibrillator can display.

Table 4-4 Describes displayed messages indicating defibrillator/monitor failures.

Table 4-5 Describes displayed messages that indicate pacer malfunction.

Table 4-6 Describes displayed messages that indicate a malfunction of the pulse oximeter.

Table 4-7 Describes failure messages that the recorder can print.

Table 4-8 Lists indications of improper use.

Table 4-9 Lists recorder problems and their symptoms.

Table 4-10 Lists symptoms of display and logic failures.

Table 4-11 Describes keypanel failures and their symptoms.

Table 4-12 Describes defibrillator problems and their symptoms.

Table 4-13 Describes indications for pacing problems.

Table 4-14 Describes indications for storage problems.

Table 4-15 Describes indications for transmission problems.

Table 4-16 Describes indications of main battery failures.

Table 4-17 Describes indications of M2480B Battery Support System failures.

Table 4-18 Describes terminal communications settings.

Table 4-19 Describes serial port commands.

Table 4-20 Describes M2478A DC Power Module problems and their symptoms.

Table 4-21 Describes M2479A AC Power Module problems and their symptoms.

**Table 4-2** **Audible Indicators**

| Tone | Cause | Possible Solutions |
|---|---|---|
| While all keypanel LEDs are lit, a beep about 1 second long. | At power-on, indicates power-on cycle is normal. | None required. |
| A continuous beep, about 7 seconds long. | At power-on, the monitor and defibrillator are not communicating. | The malfunction is probably in the monitor circuits; the defibrillator may still function properly. Replace the control board. |
| A repeating tone that alternates between two frequencies. | At any time, the unit emits this tone beginning 1 minute before shutdown due to low battery charge.<br>The battery voltage is less than 11.4 V.<br>The battery voltage is too low and the battery does not recharge. | Replace the battery.<br>Check the battery cable connections to the high voltage charger board.<br>Perform a battery capacity test using the battery support system. |

**NOTE**

Other tones normally occur because various functions are enabled. Refer to *Indicator Test* in Chapter 3 for descriptions of these tones.

**Table 4-3** **On-screen System Messages**

| Message | Possible Solution |
|---|---|
| DEFIB FAILURE | Troubleshoot defibrillator subsystems. Check Error Log and troubleshoot per error code. |
| MONITOR FAILURE | 1. Replace ECG front end/pacer board.<br>2. Replace control board. |
| PACER FAILURE | 1 Replace multifunction adhesive electrode pads.<br>2 Replace ECG front end/pacer board. |
| SPO2 FAILURE | 1 Cycle $SpO_2$ power.<br>2 Replace $SpO_2$ board. |
| SYSTEM FAILURE | Replace control board. |

**Table 4-4** **On-screen Defibrillator/Monitor Messages**

| Message | Cause | Possible Solutions |
|---|---|---|
| 50J MAX | Internal paddles are attached and the Energy Select control has been turned past 50 joules. | Defibrillator will automatically limit the charge to 50 joules (internal paddles limit). For a higher charge level, use external paddles or pads. |
| CHECK RECORDER (3 seconds). | The recorder door is open, or the recorder is out of paper. | Close the recorder door or replace the paper roll. |
| DEFIB DISARMED (3 seconds). | Defibrillator has internally discharged energy and is now disarmed. | Defibrillator normally disarms after holding the charge level for about 60 seconds. Press (Charge) to charge to the selected energy level. |
| LEADS OFF displayed on screen (3 seconds). | Loose or defective patient cable, cable connectors. | Check cable and connectors for damage. Tighten connectors as necessary. Replace damaged or defective cable. |
| LEADS OFF not indicated when wire is off. | Dirty contacts on connector for lead wires. | Ensure the contacts on the connector are clean and dry. |
| | Defective or dirty lead wire. | Clean and swap around to isolate defective leadwire. Replace defective leadwire. |
| LEADS OFF indicated (3 seconds) when wire is not off. | Poor electrode contact. | Improve patient preparation. |
| | Defective lead wire. | Remove leadwire and install shorting plug. |
| LOW BATTERY | Defibrillator is not connected to the battery or the battery voltage is below 11.8 volts DC. | Reinstall or replace the battery. |
| | Message remains with power applied | Troubleshoot battery. See Table 4-14. |
| | Message remains with power applied and POWER LED is not lit. | Do each as necessary:<br>1 Replace DC supply board.<br>2 Replace control board. |
| NO PADDLES | Paddle set is not connected to the defibrillator. | Attach external paddles, internal paddles, or pads adapter as required. |
| | Paddles set is attached, but connector lock is not in **lock** position. | Push paddle connector lock to the **lock** position. |
| | Paddles set is properly attached, but the paddles set is defective. | Replace paddles set. |
| CHECK SETUP | Lithium (backup) battery is low. | Replace lithium battery. |

**Table 4-4** **On-screen Defibrillator/Monitor Messages (Continued)**

| Message | Cause | Possible Solutions |
|---|---|---|
| CHECK BATTERY | Battery pack not fully inserted into defibrillator. | Insert battery making sure it latches. |
| | Battery pack is faulty. | 1 Perform a battery capacity test.<br>2 Replace battery. |
| SETUP LOST | The memory that stores the setup has been corrupted. Perform only the steps required to resolve. Check after each step. | 1 Restore setup by changing a parameter. Then verify that the SETUP LOST message is gone.<br>2 Replace control board. Reinstall battery. Turn on unit and change a setup parameter. Verify that the SETUP LOST message is gone.<br>3 Replace lithium battery. Reinstall main battery. Turn on unit and change a setup parameter. Verify that the SETUP LOST message is gone. |
| USE LEADS | Paddles are connected to the defibrillator and: | |
| | 1. (Sync) was pressed when PADDLES was selected. | 1. Use PADS or select LEAD I, II, or III instead of PADDLES. Press (Sync) to remove the defibrillator from sync mode. |
| | 2. Defibrillator is in sync mode and PADDLES is selected. | 2. Use PADS, or select LEAD I, II, or III instead of PADDLES. |
| | 3. Defibrillator is in Defib mode and PADDLES selected when leads are attached to the patient. | 3. Use PADS or select LEAD I, II, or III instead of PADDLES. |

**Table 4-5 On-Screen Pacer Messages**

| Message | Cause | Possible Solutions |
|---|---|---|
| ATTACH PADS | Pads adapter cable is attached. (Charge) was pressed and pads are not attached.<br>(Pacer On) was pressed and pads are not attached. | Attach the pacer pads. |
| NO PADS | Pacer is on and one of the following occurs:<br>1 No pads adapter attached.<br>2 Paddles attached.<br>3 Internal paddles attached. | Attach pads for pacing. |
| PACER FAILURE | Pacer cannot deliver the required current. | Troubleshoot pacer. |
| PADS OFF | Pads adapter cable is attached and a pad is off. | Attach pads for pacing. |
| STOP PACER | An attempt was made to change pacing mode while pacing. | Stop the pacer (press (Start/Stop) before you change the pacing mode). |

**Table 4-6 $SpO_2$ Messages**

| Message | Cause | Possible Solutions |
|---|---|---|
| SPO2 FAILURE | The unit detected a failure in $SpO_2$ subsystem hardware. This failure does not affect other parts of the unit. | Press ($SpO_2$ On/Off) twice to power cycle the $SpO_2$ subsystem. If the error happens again, replace $SpO_2$ board. |
| SPO2 SENSOR FAIL | The sensor or adapter cable is broken. | Replace the sensor or adapter cable. |
| SPO2 CABLE OFF | Sensor or cable is disconnected. | Check $SpO_2$ connections between defibrillator/monitor and the sensor cable or adapter cable. |
| Dashes appear on display instead of $SpO_2$ reading. | Can't derive measurement because:<br>• The sensor is not on the patient.<br>• No pulse is detected.<br>• The sensor is incorrectly positioned.<br>• The sensor is defective. | Check the patient for a pulse. Reapply the sensor, and make sure it is correctly positioned. If it doesn't work, replace the sensor. |
| SPO2 NOISY SIGNAL | Irregular pulse patterns.<br>Patient motion. | Reapply sensor.<br>Consider using a different sensor site. |

**Table 4-6** **$SpO_2$ Messages (Continued)**

| Message | Cause | Possible Solutions |
|---|---|---|
| SPO2 LIGHT INTERF | Too much interference from external light.<br>Damage to sensor or adapter cable. | Reapply sensor.<br>Turn off lights in the room.<br>If other options do not work, replace the sensor. |
| SPO2 LOW SIGNAL | Bad connection to patient, or patient has poor perfusion. | Check the patient for poor perfusion.<br>Reapply disposable and semi-disposable sensors.<br>Readjust reusable sensors.<br>Consider using a different sensor site. |

**Table 4-7** **Printed Failure Messages**

| Message | Possible Solutions |
|---|---|
| TEST 100J FAILED | Defibrillator test failure: delivered energy check failed or the Shock Path Redundancy test failed. Print Error Log and troubleshoot per error code. See also Table 4-12. |

**Table 4-8** **Operation Problems**

| Symptom | Cause | Corrective Action |
|---|---|---|
| Noisy lead(s): Muscle artifact. | Patient is not relaxed or skin has been irritated. | Refer to the *HP CodeMaster 100 Portable Defibrillator/Monitor User's Guide.* |
| | Low quality disposable electrodes, leadwire adapters. | Replace disposable electrodes or leadwire adapters. |
| | Defective leadwires. | Isolate defective leadwires and replace them. |
| | Noisy ECG amplifier. | Test with ECG simulator. Refer to *ECG Monitor Test* in Chapter 3.<br>Replace ECG front end/pacer board. |
| Noisy trace on paddles, paddles in pockets. | Bad paddle contact. | 1 Clean paddles and paddle contacts.<br>2 Replace ECG front end/pacer board.<br>3 Replace internal test load resistor. |
| Failed synchronized cardioversion with internal monitor test | | Replace control board. |

**Table 4-9** **Recorder Problems**

| Symptom | Cause | Corrective Action |
|---|---|---|
| Paper doesn't move. | Paper out or jammed. | Replace paper or clear paper jam. |
| | Dirty sensor lens. | Clean sensor lens. |
| | Defective sensor. | Replace recorder board or recorder assembly. |
| | Defective drive assembly. | Replace drive assembly or recorder assembly. |
| | Defective drive signals. | Replace control board. |
| | Defective communication between recorder board and motor. | Check motor to recorder board cable connector. |
| Paper moves, then stops. | Paper loaded incorrectly. | Make sure defibrillator is loaded properly with approved thermal paper. |
| | Dirty sensor lens. | Clean sensor lens. |
| | Defective sensor. | Replace recorder. |
| | Defective sensor circuit. | Replace control board. |
| Wavy diagonal lines in recorder self-test or distortion of print-outs in the time axis. | Improper meshing of gears in drive assembly or door assembly. | Replace recorder drive assembly or door assembly. Replace control board. |
| | Defective communication between recorder and control board. | Replace control board. |
| Message: CHECK RECORDER | Door is ajar. | Close door. |
| | Paper installed incorrectly. | Re-install paper. |
| | Dirty sensor lens. | Clean sensor lens. |
| | Defective communication between recorder and control board. | Check cables and connections between recorder and control board. |
| | | Replace recorder assembly. |
| | | Replace control board. |
| | Defective sensor assembly. | Replace recorder. |

**Table 4-9 Recorder Problems (Continued)**

| | | |
|---|---|---|
| Paper moves but printing is faint or absent. | Door improperly latched. | Check door latch. |
| | Paper loaded incorrectly, or non-approved or non-thermal paper installed. | Make sure defibrillator is properly loaded with approved thermal paper. |
| | Insufficient leaf spring tension or printhead out of position. | Check leaf spring on printhead for platen pressure. |
| | Defective printhead or printhead cables. | Check printhead cable connector. Replace printhead. |
| | Defective recorder board cable connector or component in recorder interface circuitry. | Check the recorder board cable connector. Replace control board. |
| Printed data is garbled. | Defective printhead. | Replace printhead or recorder assembly. |
| | Defective component in data path. | Check printhead cables. Replace control board. |
| Poor print quality or some dots not printing. | Dirty printhead. | Clean printhead. |
| | Defective printhead or printhead cables. | Check printhead cable connector or replace printhead. |
| | Defective component in recorder circuitry. | Replace recorder assembly. |
| Some dots always on. | Defective printhead. | Replace printhead or recorder assembly. |

**Table 4-10 Display and Logic**

| Symptom | Cause | Corrective Action |
|---|---|---|
| Display too dim or too bright. | Improper brightness adjustment. | Adjust brightness controls for best display appearance. |
| No brightness adjust. | Defective display assembly. | Replace display assembly. |
| All dark screen. | Contrast or brightness misadjusted. | Adjust contrast. |
| | Deflection circuits failed or video circuits failed. | 1. Replace display board.<br>2. Replace control board. |
| All dark screen. | Cable between display and control board is not connected.<br><br>CRT anode is disengaged. | 1. Replace display board.<br>2. Replace control board. |

**Table 4-11 Panel Keys**

| Symptom | Cause | Corrective Action |
|---|---|---|
| Keys won't work. | Keypanel board cable unplugged or defective. | Reconnect or replace cable. |
| | Keypanel circuit board defective. | Replace keypanel board or assembly. |
| | Control board defective. | Replace control board. |

**Table 4-12 Defibrillator Problems**

| Symptom | Cause | Corrective Action |
|---|---|---|
| No response to (Charge) key. | Paddles cable not installed. | Install cable. |
| | Lockout Error (DEFIB FAILURE). | For error code, perform, PRINT LOG in Diagnostic screen. Replace control board, high voltage charger board, or high voltage components as recommended in Table 4-1. |
| | (Charge) key not recognized. | Run Controls Test to check for recognition of (Charge) key. Replace paddles, front panel, control board as needed. |
| Delivered energy out of specification. | Improper defibrillator calibration. | Perform diagnostic test CALIBRATE DEFIB. |
| | Defective high voltage charger board. | Replace high voltage charger board. |
| | Defective control board. | Replace control board. |
| | Defective defibrillator capacitor. | Replace defibrillator capacitor. |
| Test discharge indicates a failure, external defibrillator test passes. | Internal delivered energy out of calibration. | Calibrate the peak current measurement circuitry (refer to Chapter 5, *Adjusting the Internal Delivered Energy Calibration*). |
| | Defective control board. | Replace control board. |
| Test discharge does not fail and does not indicate (Test 100J passed). | Worn contacts on paddles. | 1 Clean paddle contacts.<br>2 Replace paddles. |
| DEFIB FAILURE<br>At power up or after a discharge. | Patient relay or drive circuit failure (Error 40 or 440).<br>See warning below.<br>Unexpected voltage on defibrillator capacitor. | Check that relay control connector is plugged into high voltage board.<br><br>Replace patient relay. Replace high voltage charger board.<br><br>Replace high voltage charger board. |

**Table 4-12** **Defibrillator Problems (Continued)**

| Symptom | Cause | Corrective Action |
|---|---|---|
| Unit does not deliver energy, no failure message occurs. | Patient relay failure. | Replace patient relay. |
| Unit starts charging, but does not reach the set energy level. | Safety relay failure. | Check that safety relay control connector is plugged into high voltage board.<br><br>Replace safety rely. |

**WARNING**

**The defibrillator capacitor can store lethal amounts of energy. Be sure that this capacitor is discharged before touching high voltage components, such as the high voltage charger board, defibrillator capacitor, patient inductor, patient relay, or patient cable connector. To discharge the defibrillator capacitor:**

1. **Be sure to wear safety glasses while discharging the capacitor.**
2. **In diagnostic mode make sure that the Available Energy is 0 (the Energy Select control is in the Monitor On position).**
3. **Turn the Energy Select control to Off (Standby).**
4. **Wait 30 seconds before opening the unit.**
5. **Using two screwdrivers with insulated handles, short between points 1 and 2 for 10 seconds. Afterwards, short between points 2 and 3. See Chapter 5, Figure 5-16 for point-to-point locations.**

**Table 4-13** **Pacer Problems**

| Symptom | Cause | Corrective Action |
|---|---|---|
| QRS not detected | QRS is not in specs | These specs are:<br>QRS amplitude: 0.5 mV - 5.0 mV<br>RS width: 40 mSec - 120 mSec |
| | Pacer is in Fix Mode | Change pacer to Demand Mode |
| Heart is not captured | Output current is too low | Increase output current until heart is captured. This occurs between 50 mA- 200 mA. |
| | Pacer HR is below intransic HR | Adjust pacer HR to desired rate |
| | Misplacement of pads | Reposition the pads properly. |

**Table 4-14** **Storage Problems**

| Symptom | Cause | Corrective Action |
|---|---|---|
| ECG too noisy to store<br>(This message appears briefly on the screen) | Poor electrode contact. Dry or dirty electrodes.<br><br>Patient moving or not relaxed.<br><br>Lead wires may be picking up interference from poorly grounded equipment near the patient.<br><br>Patient cable is too close to the cardiograph or other power cords. | Use new electrodes. Abrade skin. Reapply electrodes. Check expiration date on disposable electrodes.<br>Reassure and relax the patient. Press the (Filter) key if it is configured for Artifact.<br>Route lead wires along limbs and away from other electrical equipment. Fix or move poorly grounded equipment.<br>Move the cardiograph away from the patient. Unplug the cardiograph and operate on battery power. Move other electrical equipment away from patient. Unplug electric bed. |
| "Storage system full" message appears when fewer than 30 ECGs are stored. | 30 ECGs stored in memory.<br>Storage memory gradually wears out after many thousand store/erase cycles. Consequently, ECG storage capacity decreases gradually over the life of the product. | Delete some ECGs.<br>If under warranty, call HP service. Generally, stored ECGs are retrievable. If remaining ECG storage capacity is unacceptable, call HP service. |
| Unable to store ECG<br>(This message appears briefly on the screen) | A fault exists in the storage hardware. | Call HP service |
| Unable to retrieve ECG<br>(This message appears briefly on the screen) | A fault exists in the storage hardware. | Call HP service |

**Table 4-15** **Transmission Problems**

| Symptom | Cause | Corrective Action |
|---|---|---|
| Telephone busy, re-dialing | Busy telephone number. | 12-Lead will automatically re-dial, waiting 30 seconds between attempts. |
| No answer, re-dialing | Remote modem not connected. | Report problem to remote site. |
| | Modem is set to give up after too few rings. | Check configuration of modem register S7. See your modem documentation for more information. |

| Symptom | Cause | Corrective Action |
|---|---|---|
| Check telephone cable | No dial tone. | Check the connection to the telephone system.<br>Be sure the telephone system is in operation.<br>Replace the telephone cable.<br>Check with your local telephone administrator.<br>Check that the phone has ringer equivalence number (REN) on bottom or back of phone unit to determine if telephone system is Public Switched Telephone<br>Network (PSTN). |
| Check modem and cable | No power to modem, or poor modem cable connection. | Check that the modem is turned on.<br>Check the data communication cable connections between the modem and the 12-Lead. |
| Check cable | Poor cable connection. | Check all cable connections.<br>Replace cable. |
| No modem at remote site | Remote site answered, but no modem carrier was detected, or a fax machine answered. | Verify transmission type with remote site. Check telephone number. Re-try transmission. |
| No fax at remote site | Remote site answered, but no fax machine was detected, or a modem answered. | Verify transmission type with remote site. Check telephone number. Re-try transmission. |
| Check modem configuration | Incompatible or improperly initialized modem. | Verify the modem initialization string. Refer to modem specifications in Chapter 1, "Introduction." Verify that your modem is compatible. |
| Incompatible fax machine at remote site. | The fax machine at the remote site is not a group III device. | Transmission requires a group III fax machine at remote sites. |
| Transmission stopped unexpectedly. X of N ECGs sent. Cable/modem problem. Press any key to continue. | No power to modem, or poor modem cable connection. | Check that there is power to the modem. Check the data communication cable connections. Call the other location to verify their modem is functioning correctly. |
| Transmission stopped unexpectedly. X of N ECGs sent. Modem was disconnected. Press any key to continue. | Problem with telephone line. | Check that the modem is connected to the telephone line. Verify that the telephone line is working. |
| Transmission stopped unexpectedly. X of N ECGs sent. Remote site stopped communication (nn). Press any key to continue. | Communication speed of the remote device does not match that of the 12-Lead, or remote site modem malfunction. | Call the remote location to verify that the communication speed is correct and that the modem is functioning correctly. Reduce the communication speed of both the 12-Lead and remote site modems. |

| Symptom | Cause | Corrective Action |
|---|---|---|
| Cannot send to a TraceMaster A/B, PageWriter 200/300, or PageWriter XLi using a cellular line without the use of a Gateway | Sending ECGs to these receiver types over a cellular line requires the use of a Gateway. | Configure the Gateway phone number with the number of your Gateway.<br>Change the line type on the home screen to Tone or Pulse and use a land landline. |
| The ECG Manager gateway can only receive one ECG. The first ECG has been successfully sent. | The Gateway is limited to receiving one auto forwarded ECG. | Select one ECG at a time for transmission from the Send ECGs screen. |

**Table 4-16** **Main Battery Problems**

| Symptom | Cause | Corrective Action |
|---|---|---|
| Defibrillator will not power up on battery power. | Defective battery. | 1 Replace battery.<br>2 Replace DC supply. |
| | Control board defective. | Replace control board. |
| Battery will not accept charge. | Battery is defective. | Replace battery. |
| | Battery support system failed. | See Table 4-16. |

# Troubleshooting the HP M2480B Battery Support System

The battery support system connects to the RS-232 interface via the 9-pin (DB-9) serial connector on the rear panel. The battery support system is configured as a DTE (Data Terminal Equipment) device.

If the battery support system displays the FAULT indicator, press Test for that channel to gain additional information about the fault condition. Other indicators will light to give you more information about the problem as described in Table 5-15.

**Table 4-17 M2480B Battery Support System Problems**

| Lights | Cause | Corrective Action |
|---|---|---|
| FAULT CHARGING | Battery is too cold or too hot. | Let battery come to room temperature. |
| FAULT blinking CHARGING | Battery support system is too cold or to hot. | Let battery support system come to room temperature. |
| FAULT | Battery cannot be charged. | 1 Re-test battery.<br>2 Replace battery. |
| FAULT blinking | Battery support system damaged. | Replace battery support system. |
| FAULT TESTING | Battery capacity too low during test cycle. | 1 Re-test battery.<br>2 Replace battery. |
| FAULT blinking TESTING | Calibration lost. | Replace battery support system. |
| FAULT PASS | Capacity inaccurate. | 1 Test battery in other bay of battery support system.<br>2 Replace battery.<br>3 Replace battery support system. |
| AC~ blinking or off | Low AC power. | Check voltage setting on rear of unit. |

## Configuring the Battery Support System RS-232 Interface

To configure the RS-232 interface on the PC, use a terminal program (such as Microsoft® Windows Terminal) with the HP 34398A Cable Kit. You may also use an HP Palmtop PC with an HP F1021B/C Connectivity Pack. Configure the communications setting as shown:

**Table 4-18 Terminal Communications Settings**

| Description | Setting |
|---|---|
| Baud rate | 9600 |
| Data bits | 8 |
| Number of stop bits | 1 |
| Parity | None |
| Flow control | None |
| Connector | *User selectable* (COM1:, COM2:, COM3:, COM4:) |
| Parity check | Not selected |
| Carrier detect | Not selected |

Use the serial port commands to check the state of the battery support system and the battery pack.

**Table 4-19 Serial Port Commands**

| Command | Description | Effect |
|---|---|---|
| H | Help | Lists available commands. |
| B | Batteries | Lists the battery types supported. |
| S | Status | Lists the following info for each battery:<br>• Voltage, current and temperature<br>• How long it has been charging<br>• Charger state—charge, discharge, maintain, etc.<br>• Last Measured Capacity (after capacity test) |
| T | Self Test | Resets the chip and runs the self test. |

# Troubleshooting the HP M2478A DC Power Module

**Table 4-20 M2478A DC Power Module Problems**

| Problem | Cause | Possible Solutions |
|---|---|---|
| Power indicator on Portable Defibrillator/ Monitor does not appear. | Portable Defibrillator/Monitor is not receiving power. | 1 Check connections.<br>2 Check fuse.<br>3 Check that vehicle power supply voltage is within range.<br>4 Call your local HP service representative to replace the Portable Defibrillator/ Monitor. |
| Charging indicator does not appear. | Battery is not charging. | 1 Make sure that external power is on.<br>2 Check connections.<br>3 Make sure battery is properly installed in the defibrillator.<br>4 Make sure battery temperature is less than 60° C (140° F).<br>5 Replace the battery with another battery.<br>6 Call your local HP service representative to replace the Portable Defibrillator/Monitor. |
| Fuse opens. | Installed with incorrect polarity. | 1 Replace fuse.<br>2 Install with correct polarity. |
| | Electrical problems during operation. | 1 Replace fuse.<br>2 Check vehicle power supply.<br>3 Call your local HP service representative to replace the Portable Defibrillator/Monitor. |

# Troubleshooting the HP M2479A AC Power Module

## Fuse Replacement

The AC Power Module has two fuses that may be replaced in the field. The fuses and their locations are:

- 10A Fast Blow fuse (HP2110-0051) located on the bottom of the AC Power Module.
- 5A Fast Blow fuse (HP2110-0709) located under the power cord strain relief on the back of the AC Power Module.

## Troubleshooting Tables

Tables 4-19 and 4-20 provide AC power troubleshooting hints.

**Table 4-21 AC Power Module Problems**

| Problem | Cause | Possible Solutions |
|---|---|---|
| Power and charging indicators do not light on the AC Power Module | AC Power Module is not receiving power or a fuse has blown. | 1 Make sure the AC Power Module is plugged in.<br>2 Replace the fuses (see above).<br>3 Call HP for service. |
| Charging indicator does not light; power indicator is lit. | Battery is not charging. | 1 Check connections to the defibrillator.<br>2 Make sure battery is properly installed in the defibrillator.<br>3 Replace the battery, it may need reconditioning.<br>4 Make sure battery temperature is less than 60° C (140° F).<br>5 Call HP for service. |

**Table 4-22 Defibrillator Problems**

| Problem | Cause | Possible Solutions |
|---|---|---|
| External power indicator on defibrillator does not appear. | Defibrillator is not receiving power. | 1 Check that the AC Power Module power indicator is On. If not, troubleshoot according to Table 4-19.<br>2 Check connections.<br>3 Call HP for service. |
| Charge time is greater than 15 seconds with battery removed. | Battery is not charging. | 1 Check connections.<br>2 Call HP for service. |

# Removal and Replacement

## Introduction

This chapter provides procedures for removing and replacing these assemblies:

- Battery Pack
- 12-Lead Bezel Assembly
- Recorder Assembly
- Recorder Platen Assembly
- Bottom Cover
- Front Bezel
- Monitor Keypanel Assembly
- Defibrillator Keypanel Assembly
- Energy Switch
- Pacer/$SpO_2$ Keypanel Assembly
- ECG and $SpO_2$ Cables
- Lithium Battery
- Control Board
- High Voltage Charger Board
- DC Supply
- $SpO_2$ Board
- Mid-PAC Assemblies
- Patient Inductor
- Safety Relay
- ECG Front End/Pacer Board
- Patient Relay
- CRT Assembly
- ECG System Board
- Defibrillator Capacitor
- Keypanel Cable
- Testload Resistor

**NOTE**

This chapter also includes a calibration procedure for internal delivered energy, which should be performed after completing any M2475B maintenance task.

**WARNING**

**Dangerous voltages may be present on components and connections during unit disassembly. Use extreme caution while the unit cover is removed.**

**CAUTION**

If you do not reassemble the instrument correctly, the instrument may no longer be water sealed. This could result in water damage to the defibrillator. Be sure to maintain the water seal on the defibrillator after reassembly by

- Replacing gaskets
- Correctly assembling gaskets (making sure they are not pinched)
- Replacing all screws
- Making sure that screws are not cross-threaded

**NOTE**

How the wires and cables are routed and dressed inside the chassis plays an important part in reducing electromagnetic and radio frequency interference emitted by the defibrillator. When you disassemble any part of the defibrillator, pay special attention to how cables and wires are routed. When you reassemble the defibrillator, be sure to route and dress all cables and wires as they were originally. There are paths within the HP-PAC for certain cables and wires. Return all components to their former position within the packaging material.

## Tool Requirements

You will need the following tools to perform the procedures given.

- T10 and T15 drivers (or Torx driver kit, HP part number 5181-1933).
- 7/32" and 1/2" nutdrivers.
- Insulated flat-tip screwdriver.
- Long-nose pliers with insulated handles (for discharging the CRT).
- Split drivers for connector removal (HP part number 5181-1933).
- High voltage discharge tool for discharging the defibrillator capacitor (HP part number M2475-69572).

**CAUTION**

Be sure to work in a static free environment. Use an electrostatic wrist band. The work surface and area surrounding it must be static free.

# Removing the Battery Pack

To remove the battery:

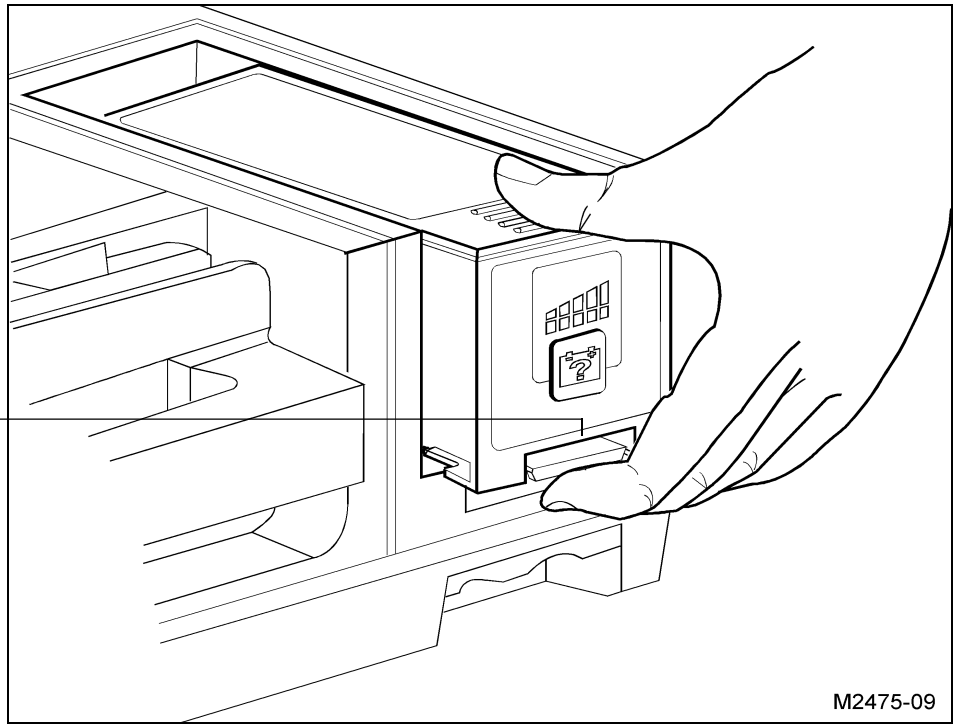
**1** Grasp the battery, as shown in Figure 5-1.

**2** Lift the battery locking latch and pull the battery out.

**NOTE**

If the battery is not properly seated in the battery compartment the unit displays the warning message CHECK BATTERY accompanied by an audible warning when you power on the unit.

**Figure 5-1**




Battery locking latch. Lift the locking latch in the direction indicated by the arrow to remove the battery.

**Removing the Battery**

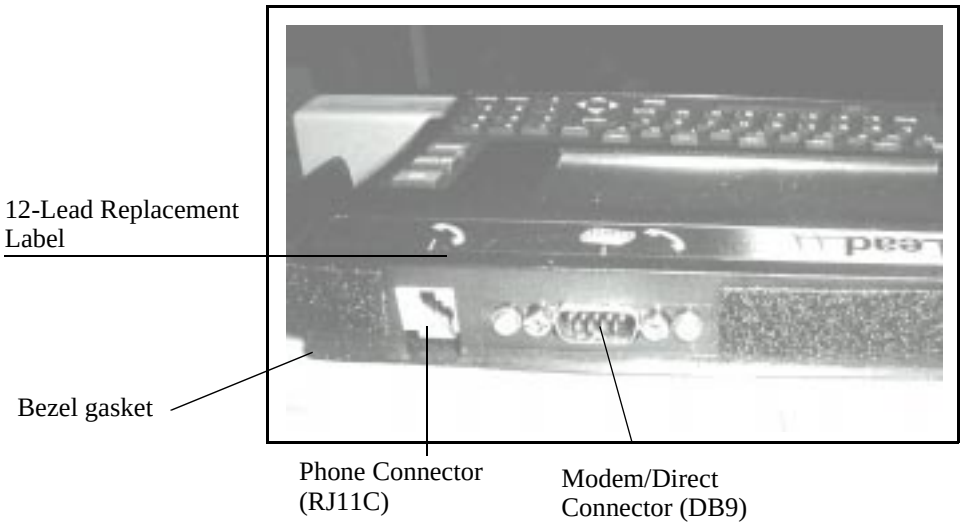
# Removing the 12-Lead Bezel Assembly

The 12-Lead bezel assembly is composed of the keyboard, front panel, phone connector (RJ11C) and the modem/direct connector (DB9). To replace any of the components on the bezel, you must first remove the bezel assembly from the defibrillator chassis. The bezel assembly can be removed without opening the defibrillator chassis.

To remove the 12-Lead bezel assembly:

**1** Remove the12-Lead replacement label. See Figure 5-2. You may discard this label as each new bezel assembly comes with a set of localized replacement labels (M2475-84710).

**Figure 5-2**




**Rear View 12-Lead Bezel Assembly**

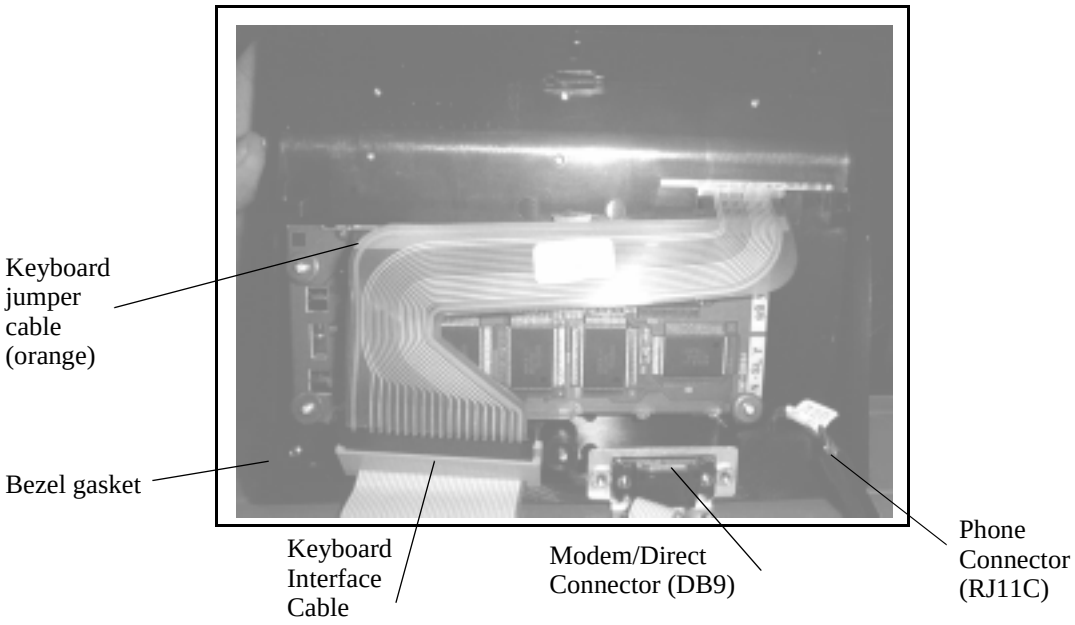
**2** Using a Torx T10 screwdriver, remove the three screws beneath the 12-Lead replacement label.

**3** Using a Torx T10 screwdriver, remove the two outside screws on the modem/direct connector (DB9).

**4** Apply a downward forward motion to loosen the three clips at the front and the two clips at the center of the 12-Lead bezel base assembly. Be sure bezel gasket lifts up with the bezel assembly.

**5** Tilt the 12-lead bezel assembly up and forward from the front of the unit. See Figure 5-3.

**Figure 5-3**

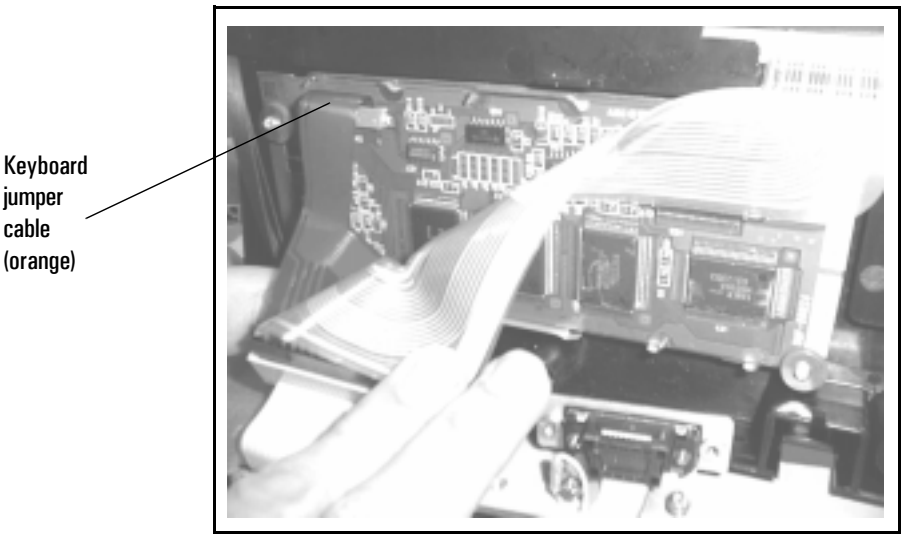



**Underside View 12-Lead Bezel Assembly**

**6** Disconnect the phone connector (RJ11C).

**7** Using a long nose type pliers, disconnect the keyboard interface cable. Be careful not to remove the keyboard jumper cable (orange) from the 12-Lead bezel assembly board. See Figure 5-4.

**Figure 5-4**




**Close up of 12-Lead Keyboard Jumper Cable**

**8** Lift the12-Lead bezel assembly from the top of the defibrillator unit.

To replace the12-Lead bezel assembly, perform the procedure for *Removing the 12-Lead Bezel Assembly* in reverse order.

To replace the 12-Lead bezel assembly:

**1** Using a long nose type pliers, connect the keyboard interface cable. Be careful not to remove the keyboard jumper cable (orange) from the 12-Lead bezel assembly board.

**2** Connect the phone connector (RJ11C).

**3** Apply a downward forward motion to secure the three clips at the front and the two clips at the center of the 12-Lead bezel base assembly. You may need to use a thin flat head screwdriver to realign the bezel gasket to the bezel assembly unit.

**4** Align the three screw holes beneath the 12-Lead replacement label. Using a Torx T10 screwdriver, replace these three screws.

**5** Using a Torx T10 screwdriver, replace the two outside screws on the modem/direct connector (DB9).

**6** Attach the appropriate localized 12-Lead replacement label (M2475-84710) provided with each new bezel assembly.

# Removing the Recorder Assembly

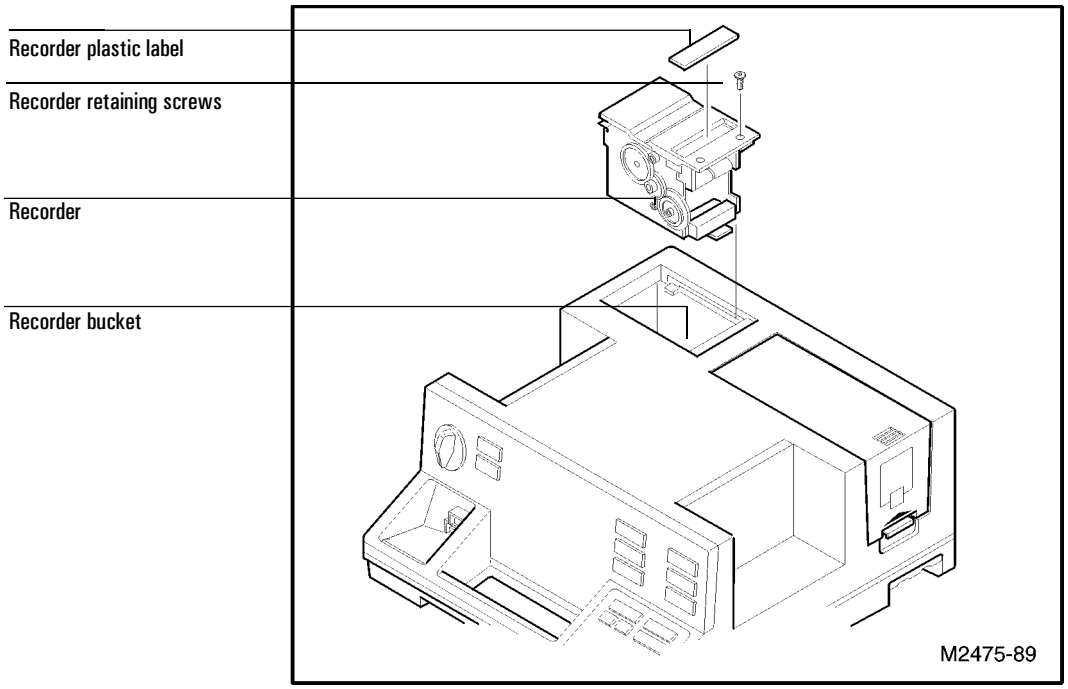
The recorder assembly is composed of the recorder and the recorder sliding door. To replace any of the components on the recorder, you must first remove the recorder from the defibrillator chassis. The recorder can be removed without opening the defibrillator chassis.

To remove the recorder:

**1** Remove the plastic label that covers the two screw holes. See Figure 5-5.

**2** Using a Torx T10 screwdriver, remove the four screws that secure the recorder to the chassis. (Open the recorder door to access the back two screws.) Lift the recorder from the recorder bucket and disconnect the ribbon cable.

**Figure 5-5**




**Removing the Recorder**

**3** To remove the recorder sliding door, turn the recorder upside down so that the sliding door is facing you and the paper roll is facing away. Note how the springs are installed on the sliding door and how the metal door limit is used to stop the travel of the sliding recorder door (the springs are identical).

**4** Using a pair of needle-nose pliers, remove and save both springs.

**5** Lift the door travel limiter up and slide the door forward, away from the recorder.

**6** Pull the retaining clips on one side of the door away from the recorder frame so that the door is free of the recorder.

**7** To remove the side of the door with the roller, squeeze the frame together at that end to free the door from the metal pins. Remove and save both springs.

To replace the recorder and recorder sliding door, perform the procedure for *Removing the Recorder Assembly* in reverse order.

## Removing the Recorder Platen Assembly

To remove the Recorder Platen Assembly:

**1** Perform the procedure *Removing the Recorder Assembly*.

**2** Open the platen assembly so that the print head is visible.

**3** Grasp the body of the recorder with the right hand and squeeze the body so that the hinge pins move in. When the hinge pins disengage from the platen assembly, lift the platen assembly from the hinges.

To replace the platen assembly, perform the *Removing the Recorder Platen Assembly* procedure in reverse order.

# Removing the Bottom Cover

To remove the bottom cover and open the defibrillator chassis.

**WARNING**

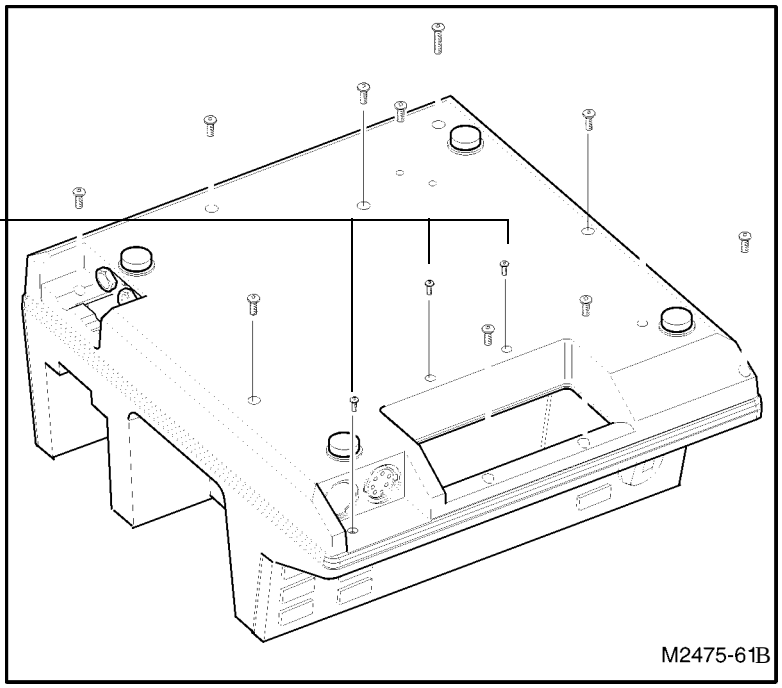
**Before disassembly, check the defibrillator charge. Use the *Delivered Energy Level Test* (refer to Chapter 3) to verify that the available energy is zero.**

1 Perform the procedure for *Removing the Battery Pack.*

2 Remove the paddles and paddles connector.

3 Using a Torx T10 screwdriver, remove three flat head and ten pan head screws that secure the upper and lower parts of the chassis. See Figure 5-6.

**Figure 5-6**




**Bottom Cover Removal and Replacement**

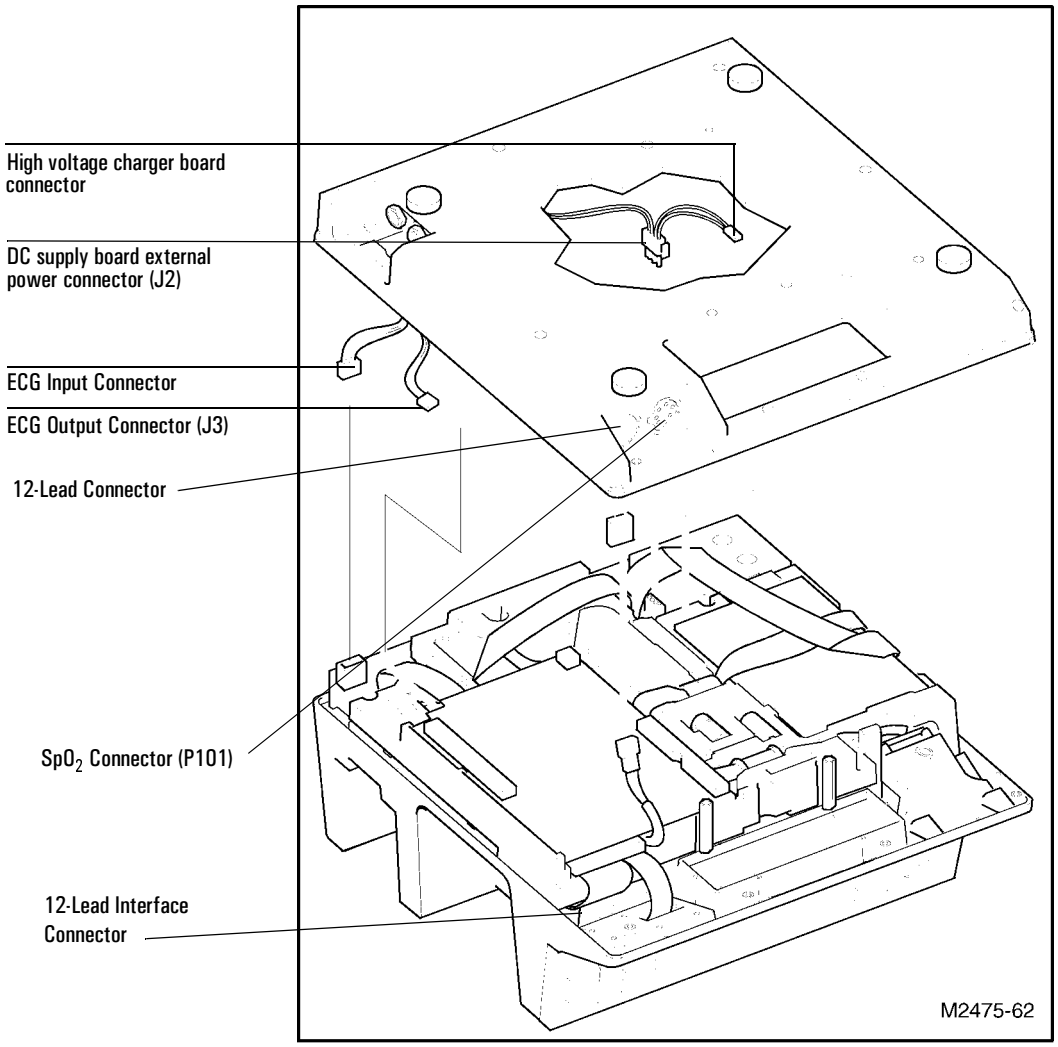
4 Grasp the handle securely and slowly tilt the chassis upright. This causes the 13 screws to pull out of the chassis. Perform this step slowly to avoid losing the screws. Collect the screws and save for reassembly.

**CAUTION**

Be careful when opening the bottom cover. Ribbon cables and ground wires connect the bottom of the chassis and internal components.

**5** Partially open the bottom cover (see Figure 5-6). Disconnect the cable assembly attached to P101 on the $SpO_2$ board as shown in Figure 5-7.

**Figure 5-7**




**Bottom Cover Cable Connections**

**6** At the control board, disconnect the ribbon cable that runs between J3 on the control board and the ECG output connector.

**7** Disconnect the cable from the DC supply J2.

**8** Disconnect the cable from the high voltage charger board. You can now separate the chassis top and bottom.

To replace the bottom cover, perform the procedure for *Removing the Bottom Cover* in reverse order. Be careful to seal the halves of the case correctly to maintain the water-resistance of the unit.

## Removing the Front Bezel

To replace any of the components on the front bezel you must first remove the bezel from the defibrillator chassis.

**WARNING**

**Removing the front bezel breaks the water tight seal for the defibrillator. When assembling the front bezel, replace all labels to ensure a water tight seal. Make sure the gaskets are properly installed.**

To remove the front bezel:

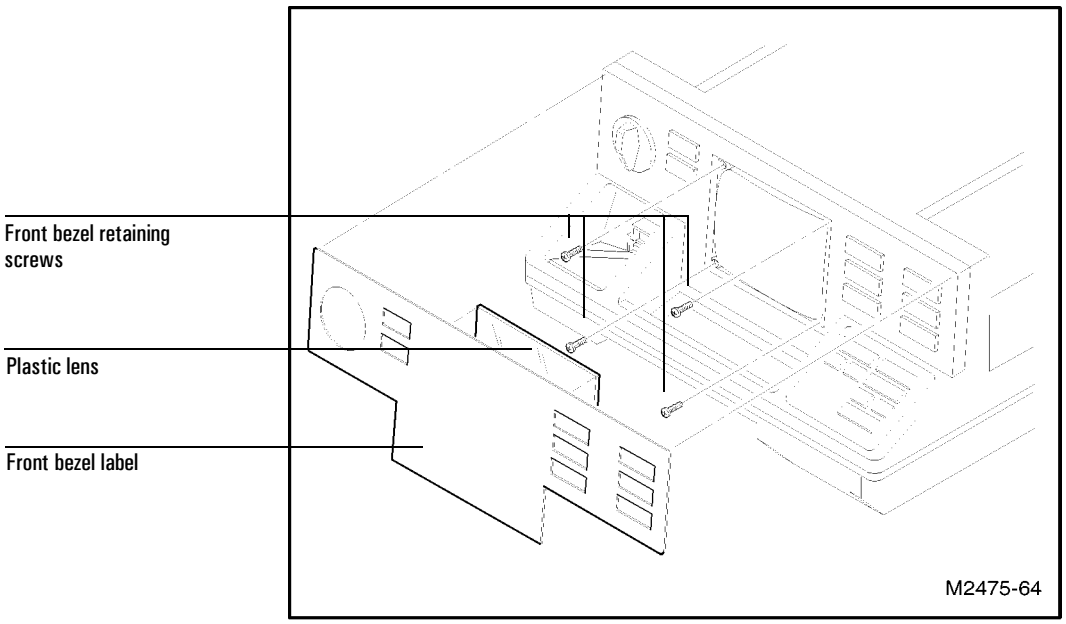
1 Carefully remove the front bezel label and plastic lens that cover the four screw holes. See Figure 5-6. Use a flat tip screwdriver to carefully separate the label from the rubber keypads.

**CAUTION**

There is a plastic lens behind the front bezel label which might break if you drop it.

2 Perform the procedure for *Removing the Bottom Cover*.

**Figure 5-8**

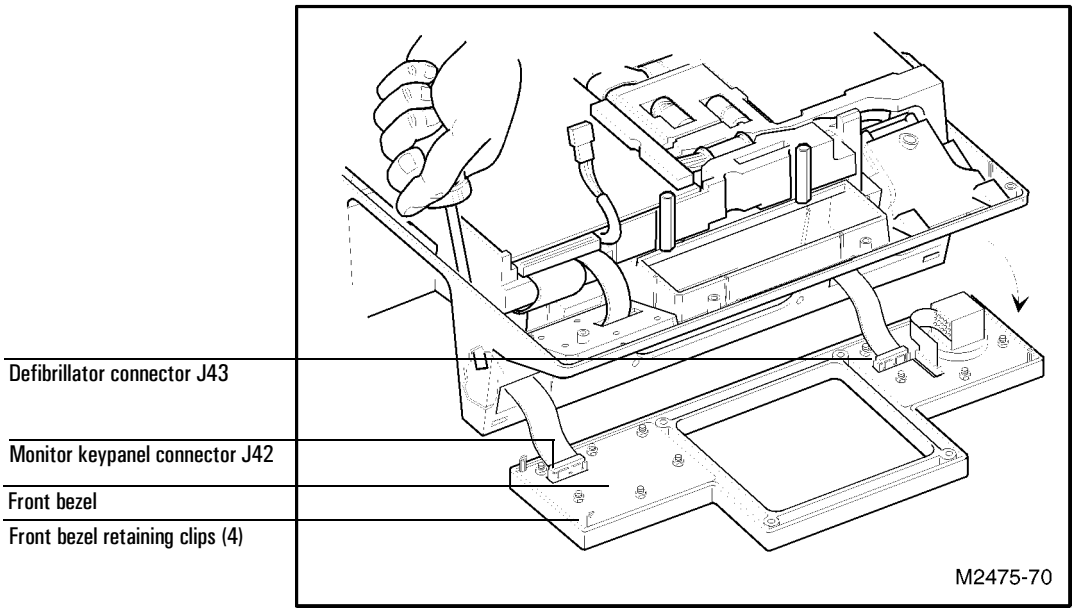



**Removing the Front Bezel Label and Retaining Screws**

**3** Remove the four retaining screws, shown in Figure 5-8, that connect the front bezel to the CRT.

**4** Detach the four retaining clips that hold the front bezel to the defibrillator chassis (see Figure 5-9).

**Figure 5-9**




**Detaching the Front Bezel Clips and Connectors**

**5** Remove the monitor keypanel connector J42 and the defibrillator keypanel connector J43. Be careful that the cable connectors are also removed.

To replace the front bezel, perform the procedure for *Removing the Front Bezel* in reverse order. Attach a new front bezel label to make a water-tight seal.

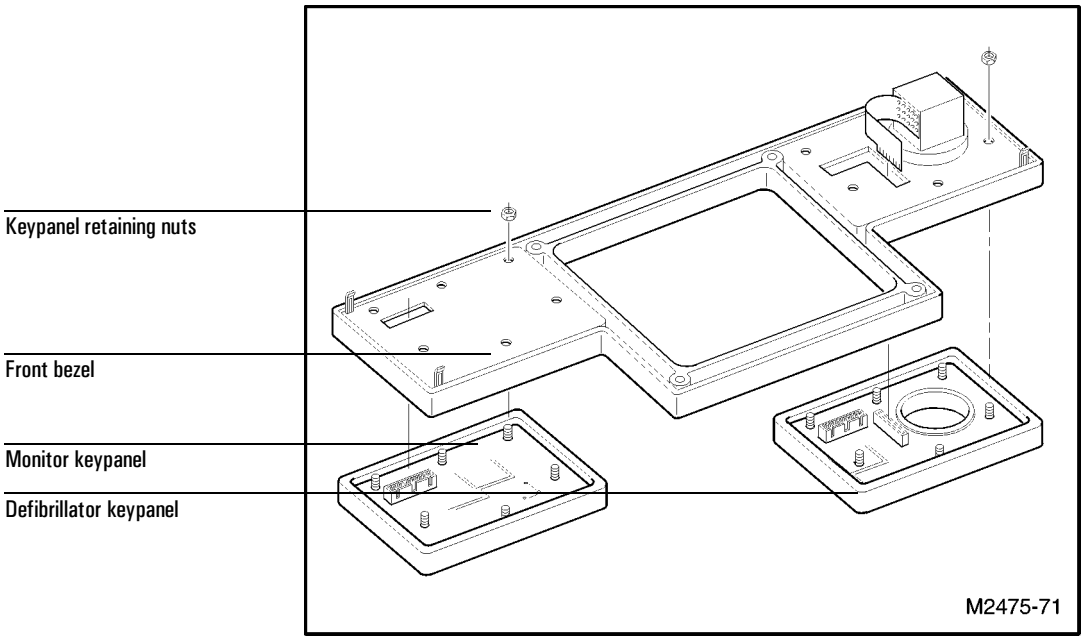
## Removing the Monitor Keypanel Assembly

The monitor keypanel assembly consists of a small circuit board and the rubber keypanel. To remove the monitor keypanel assembly:

**1** Perform the procedure for *Removing the Front Bezel*.

**2** Using a 3/32” nutdriver, remove the six nuts that retain the keypanel assembly to the front bezel. See Figure 5-10.

**Figure 5-10**




**Keypanel Assembly**

**3** Remove the monitor keypanel from the front keypanel assembly.

To install the monitor keypanel assembly, perform the procedure for *Removing the Keypanel Assembly* in reverse order.

# Removing the Defibrillator Keypanel Assembly

The defibrillator keypanel assembly consists of a small circuit board, the power switch, and the rubber keypanel. To remove the defibrillator keypanel assembly:

**1** Perform the “Removing the Front Bezel” procedure.

**2** The defibrillator keypanel board and keypanel are secured with six nuts (see Figure 5-10). Using a 3/32” nut driver, remove these nuts to disassemble the keypanel assembly.

**3** To remove the defibrillator keypanel, first disconnect the flexible circuit cable that connects the circuit board to the Energy Control switch. Using a small, insulated flat-tip screwdriver, unhook the connector.

**4** Remove the defibrillator keypanel from the front keypanel assembly.

To assemble and install the defibrillator keypanel assembly, perform the procedure for *Removing the Defibrillator Keypanel Assembly* in reverse order.

# Removing the Energy Switch

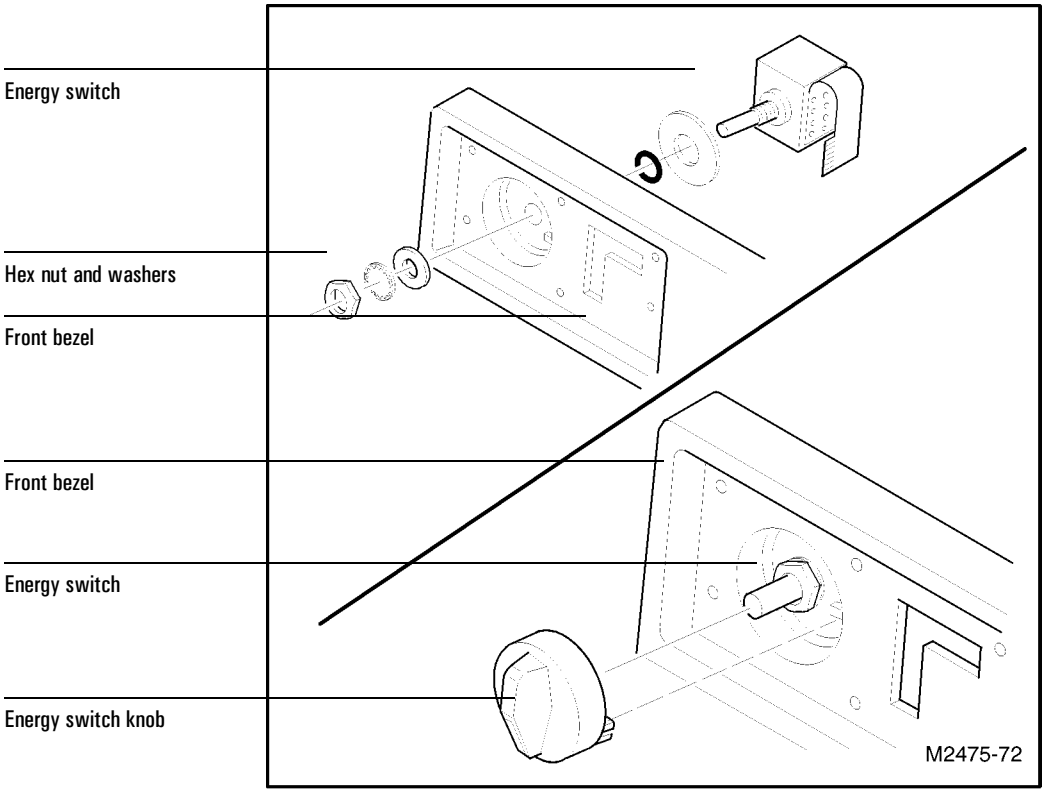
To remove the energy switch:

**1** Perform the procedure for *Removing the Front Bezel*.

**2** Disconnect the flexible circuit cable that connects the energy switch to the defibrillator keypanel. Use a small, insulated flat tip screwdriver.

**3** Remove the energy select switch knob. See Figure 5-11. Use 2 small, flat tip screwdrivers to pry knob off.

**Figure 5-11**




**Energy Switch Removal**

**4** Remove the 1/2” hex nut, locking washer, and washer from the energy switch.

**5** Slide the energy switch assemble through the rear of the defibrillator keypanel assembly.

To replace the energy switch, perform the procedures for *Removing the Front Bezel* and *Removing the Energy Switch* in reverse order.

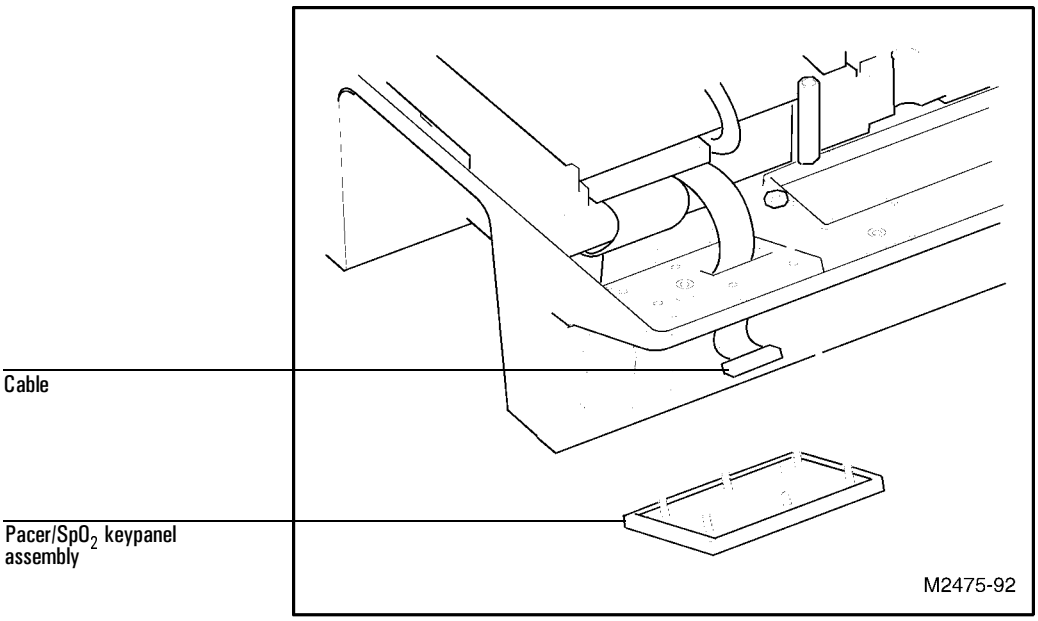
# Removing the Pacer/$SpO_2$ Keypanel Assembly

The pacer/$SpO_2$ keypanel assembly consists of a small circuit board and the rubber keypanel. To remove the pacer/$SpO_2$ keypanel assembly:

**1** Perform the procedure for *Removing the Bottom Cover*.

**2** Disconnect the cable running between the control board and the pacer/$SpO_2$ keypanel assembly.

**Figure 5-12**




**Pacer/$SpO_2$ Keypanel Assembly**

**3** Using a 7/32” nutdriver, remove the six nuts that secure the pacer/$SpO_2$ keypanel assembly (see Figure 5-12).

**4** Remove the pacer/$SpO_2$ keypanel assembly from the top case.

To install the pacer/$SpO_2$ keypanel assembly, perform the procedure for *Removing the Pacer/$SpO_2$ Keypanel Assembly* in reverse order.

# Removing the ECG and $SpO_2$ Cables

To remove either the ECG or the $SpO_2$ cable:

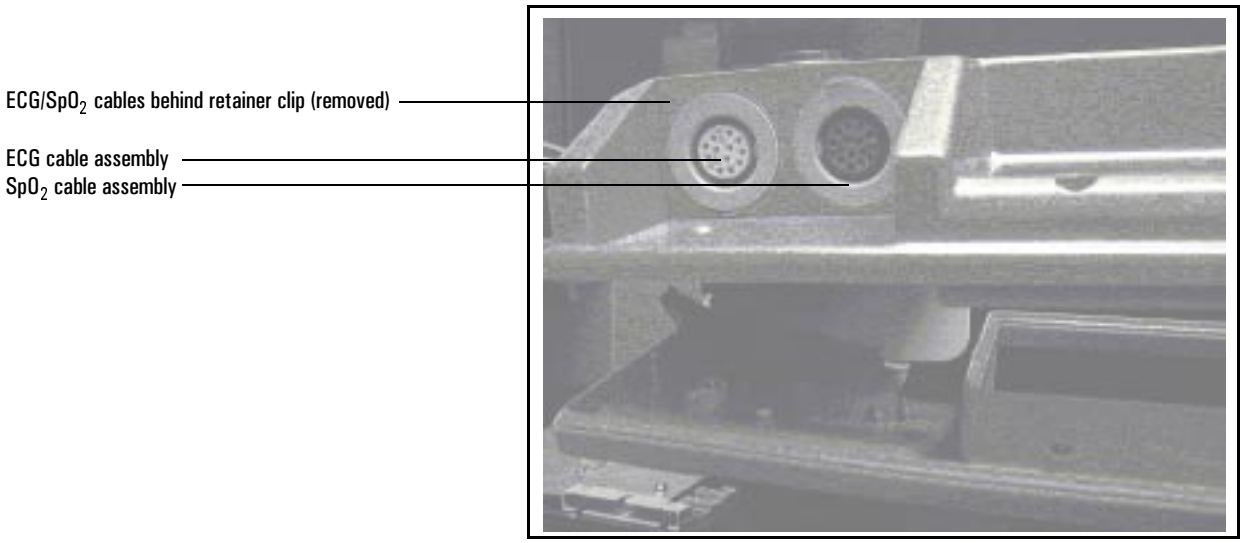
**1** Perform the procedure for *Removing the Bottom Cover*.

**CAUTION**

When replacing either the $SpO_2$ or the ECG cable the gasket must also be replaced.

**2** Push in on the cable retainer clips while lifting the clip from the cable. See Figure 5-13.

**Figure 5-13**




**ECG and $SpO_2$ Cables Removal**

**3** Remove the clip from behind the connector.

**4** Slide the cable assembly forward through the opening.

To replace the ECG or $SpO_2$ cables, perform the procedure for *Removing the ECG and $SpO_2$ Cables* in reverse order.

## Removing the Lithium Battery

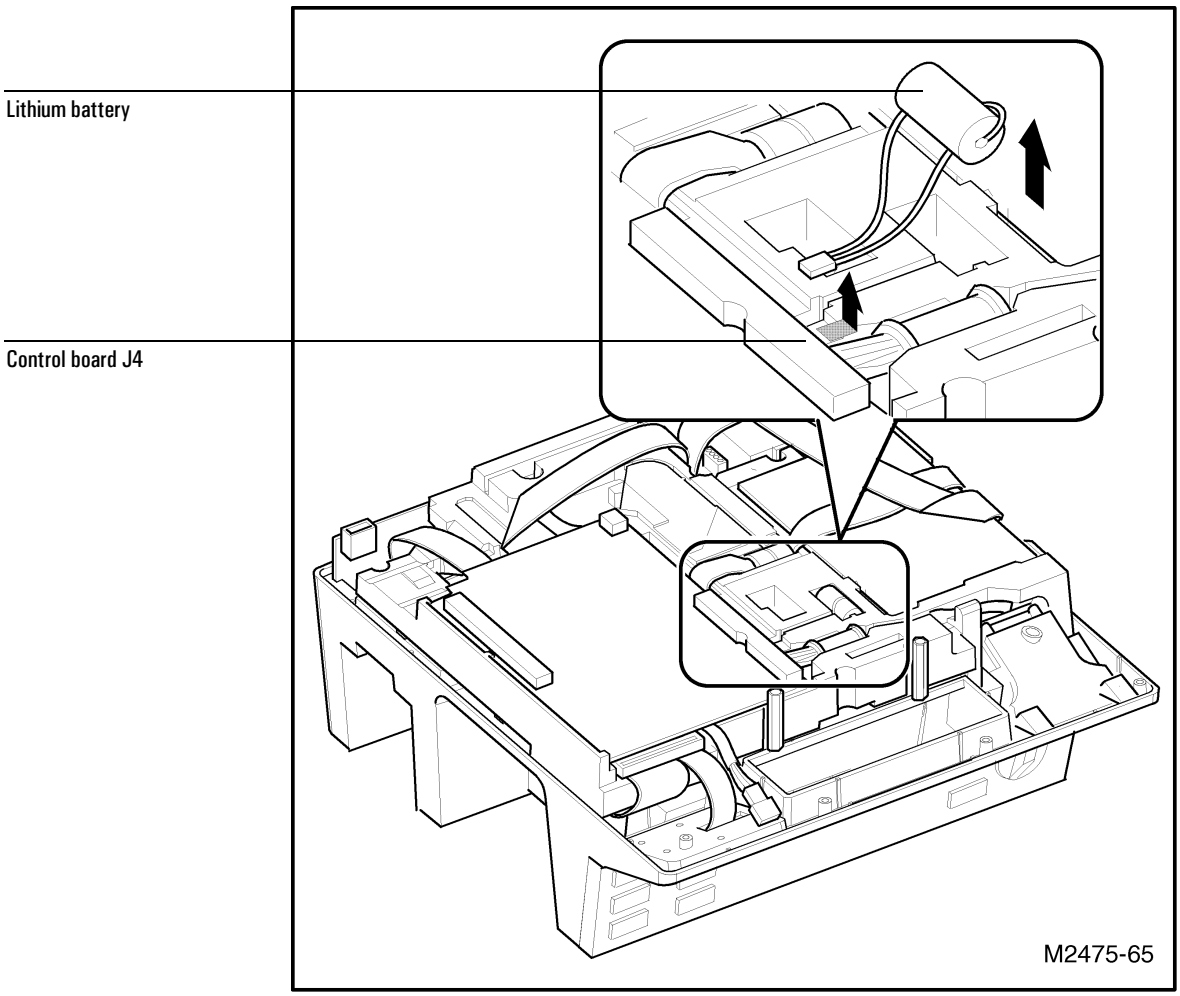
The lithium battery (HP part number M2475-62604) is located within the HP-PAC as shown in Figure 5-14. This battery provides voltage to memory which stores setup information. The lithium battery's typical life expectancy is 10 years when the instrument is operated at 25° C and the main battery pack is removed from the instrument for no more than 4 hours continuous per day.

To replace the battery, perform the following steps.

**WARNING**

**Observe all lithium battery warnings. There is a risk of fire, explosion, or burns. Do not recharge, disassemble, heat above 100° C (212° F), incinerate, or solder directly on the cell. Do not short circuit the battery.**

**Figure 5-14**




**Replacing the Lithium Battery**

**1** Print the current parameter settings, if valid. Use this print-out to restore the correct settings after replacing the battery. Refer to Chapter 2, *Displaying/Printing Configuration Settings* for instructions on printing the current settings.

**2** Perform the procedure for *Removing the Bottom Cover*.

**3** The lithium battery is located inside the PAC next to the control board, as shown in Figure 5-14.

**4** Unlatch and remove the cable connection to J4 on the control board.

To replace the lithium battery, perform the procedure for *Removing the Lithium Battery* in reverse order.

**WARNING**

**Replace the lithium battery only with an approved HP battery, or damage to the unit may result.**

When you turn on the defibrillator, it displays a message indicating that system settings have been lost. Refer to Chapter 2, *Changing Configuration Settings* for instructions on restoring system settings. Use the printout of system settings obtained in step 1 of this procedure.

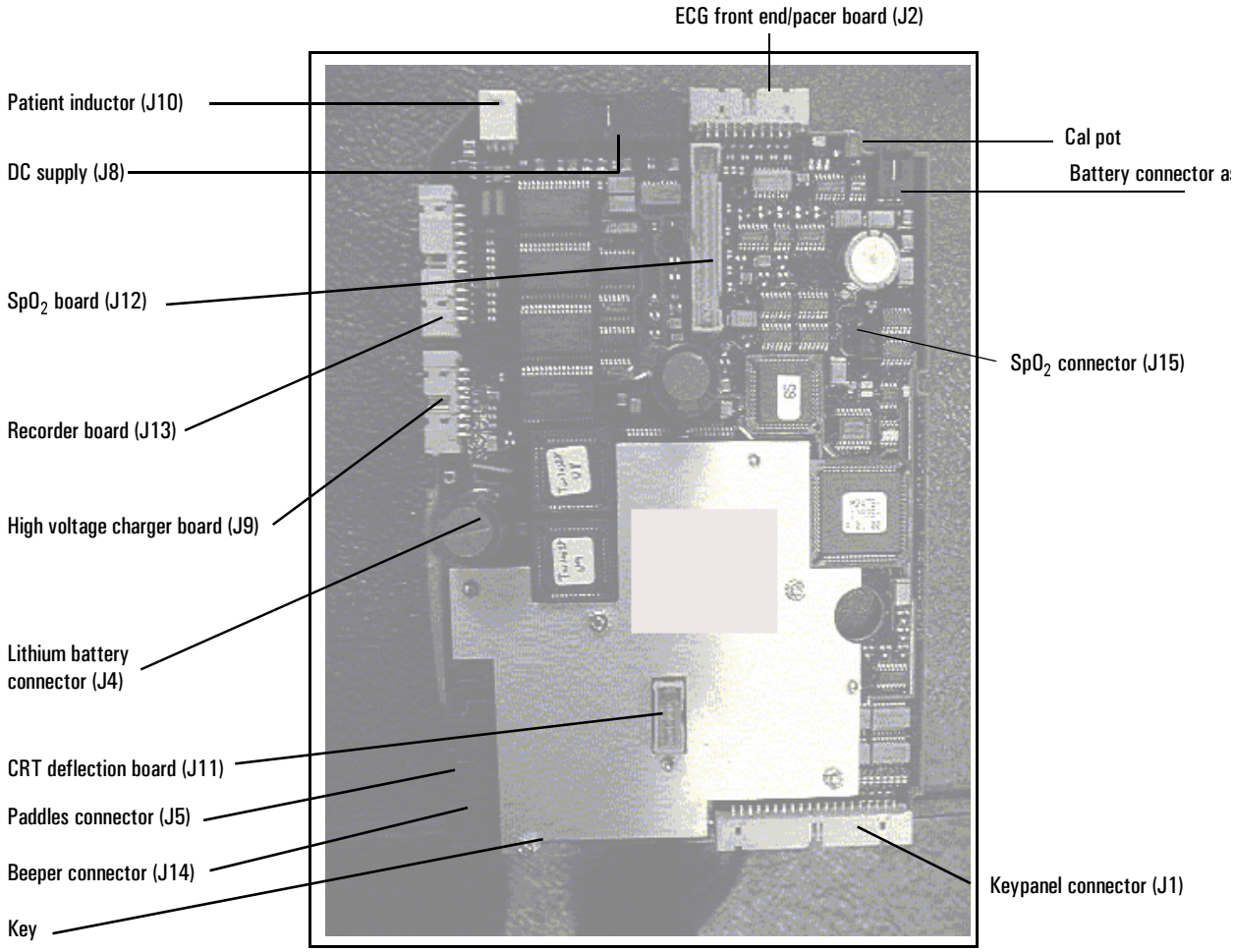
# Removing the Control Board

The control board is located in the Control PAC of the Mid-PAC assembly. The removal sequence for the connectors is critical because some connectors cannot be removed unless other connectors are removed first. To remove the control board:

**NOTE**

This view of the control board is oriented with the component side up, and the front of the defibrillator facing the user. The board is keyed by the half-moon cut-away.

**Figure 5-15**




### Removing the Control Board Cables and Connectors

1 Perform the procedure for *Removing the Bottom Cover* and *Removing the DC Supply*.

2 Remove the keypanel connector J1. See Figure 5-15.

**3** Unlatch and remove the ECG front end/pacer board connector J2.

**4** Unlatch and remove the DC supply connector J8.

**5** Unlatch and remove the patient inductor connector J10.

**6** Remove the recorder board connector J13.

**7** Remove the high voltage charger board connector J9.

**8** Unlatch and remove the beeper connector J14.

**9** Unlatch and remove the paddles connector J5.

**10** Unlatch and remove the lithium battery connector J4.

**11** While facing the front of the unit, partially lift the control board. Disconnect the cable assembly attached to J15 on the $SpO_2$ board. It is important to reconnect the cable assembly attached to J15 on the $SpO_2$ board for the $SpO_2$ option to work.

**12** Remove the CRT deflection board connector J11.

**13** Remove the SpO2 board connector J12.

To replace the control board, perform the procedure for *Removing the Control Board* in reverse order.

# Removing the High Voltage Charger Board

The high voltage charge board is located in the High Voltage PAC of the Mid-PAC assembly. The removal sequence for the connectors is critical because some connectors cannot be removed unless other connectors are removed first.

To remove the high voltage charger board:

**1** Perform the procedure for *Removing the Bottom Cover* and *Removing the DC Supply*.

**2** Remove control board connector J2.

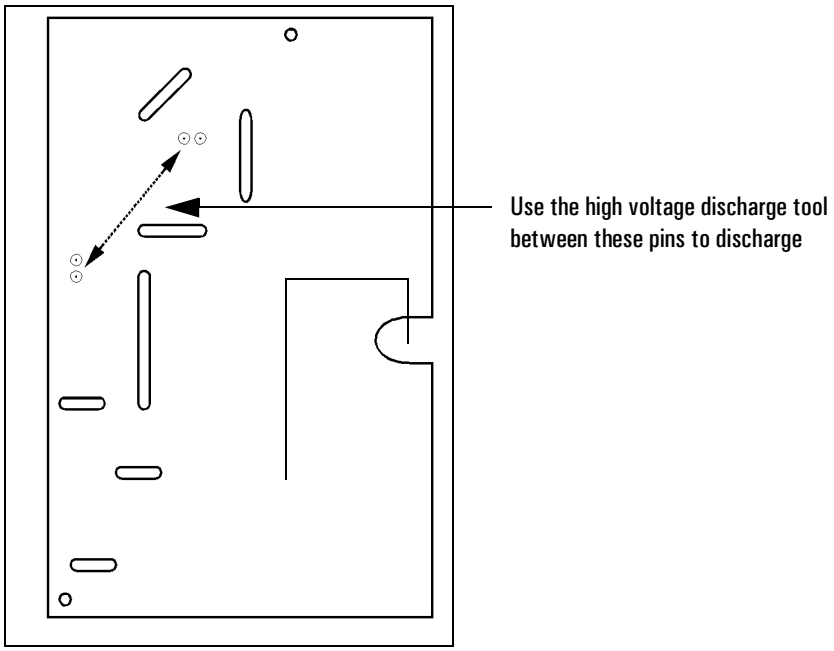
**3** Remove the high voltage shield from the high voltage charger board.

**4** Use the high voltage discharge tool (HP M2475-69572) to discharge the defibrillator capacitor as shown in Figure 5-16. If you do not have this tool, wait one hour after removing the battery for the voltage to dissipate.

**WARNING**

**High voltages may be present on this board. Use extreme caution when discharging. Wear safety glasses when discharging.**

**Figure 5-16**



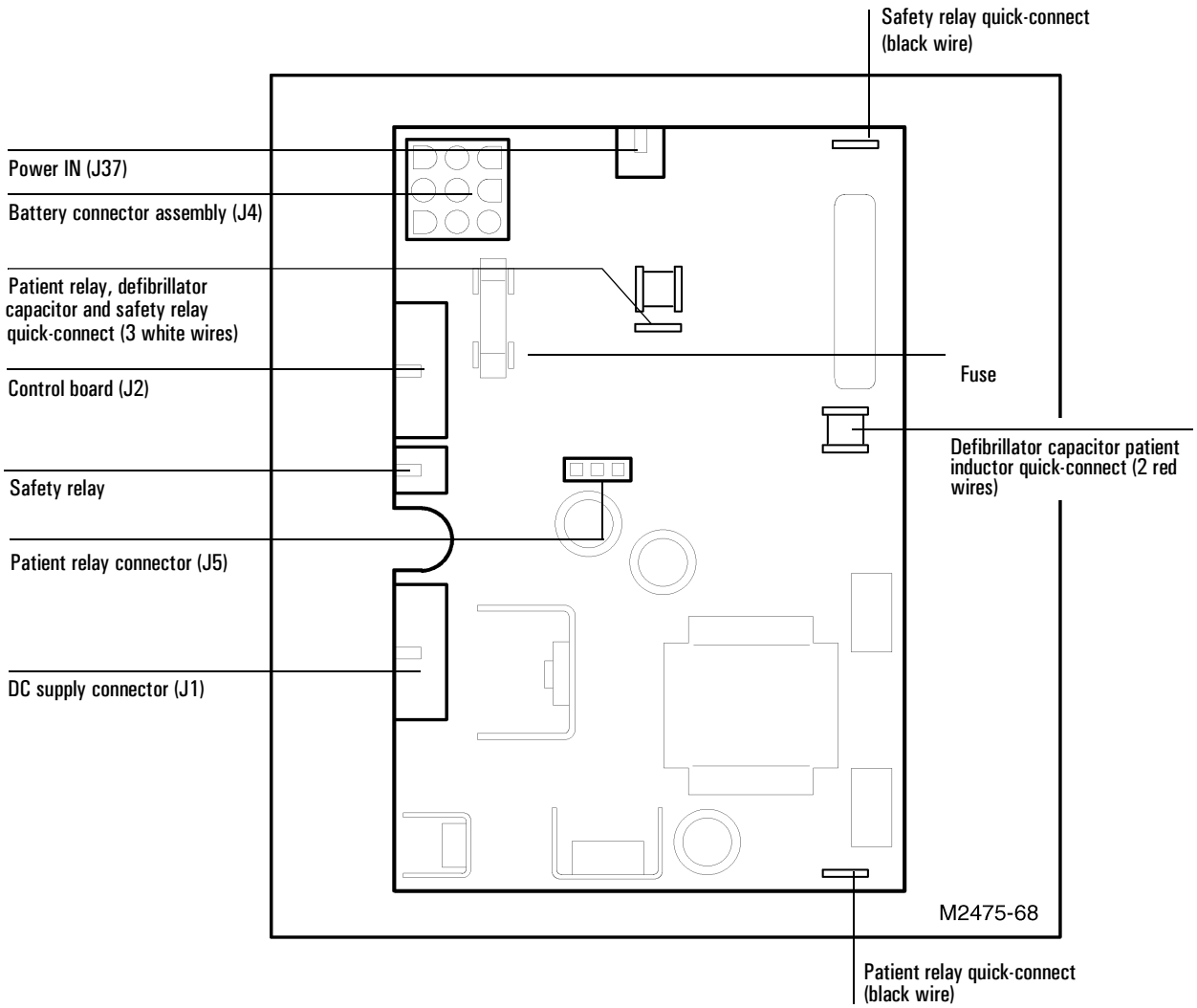

**High Voltage Charger Board Removal**

**5** Disconnect the cable assembly attached to DC supply (J1). See Figure 5-17.

**NOTE**

This view of the high voltage charger board is oriented with the component side up and the front of the defibrillator facing the users. The board will be component side down when completing these steps.

**Figure 5-17**


Safety relay quick-connect (black wire)
Power IN (J37)
Battery connector assembly (J4)
Patient relay, defibrillator capacitor and safety relay quick-connect (3 white wires)
Control board (J2)
Safety relay
Patient relay connector (J5)
DC supply connector (J1)
Fuse
Defibrillator capacitor patient inductor quick-connect (2 red wires)
M2475-68
Patient relay quick-connect (black wire)

**High Voltage Charger Board Connector Locations**

**6** Unlatch and remove the safety relay connector.

**7** Remove the battery connector J4.

**8** Unlatch and remove the patient relay control connector J5.

**9** Remove the three white wires from their quick-connects (patient relay, defibrillator capacitor, and safety relay.

**10** Remove the two red wires from their quick-connects (defibrillator capacitor and patient inductor.

**11** Remove the safety relay black wire quick-connect.

**12** Remove the black patient relay wire quick-connect.

To replace the high voltage charger board, perform the procedure for *Removing the High Voltage Charger Board* in reverse order.

# Removing the DC Supply

To remove the DC supply:

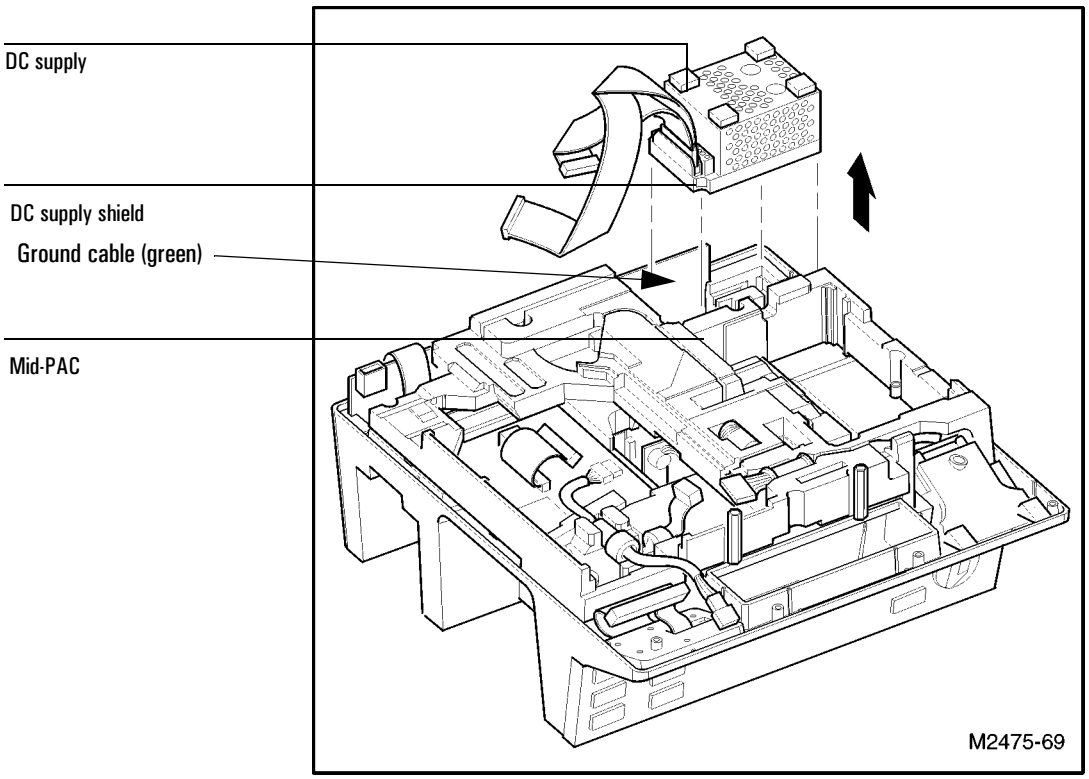
**1** Perform the procedure for *Removing the Bottom Cover*.

**2** Lift the DC supply from its position in the mid-PAC as indicated in Figure 5-18.

**3** Remove ground cable (green).

**4** Remove the DC supply shield.

**Figure 5-18**




### DC Supply Board Removal

To replace the DC supply, perform the procedure for *Removing the DC Supply* in reverse order.

# Removing the $SpO_2$ Board

The $SpO_2$ board fits into the mid-PAC assembly. To remove the $SpO_2$ board:

**1** Perform the procedures for *Removing the Control Board, Removing the High Voltage Charger Board* and *Removing the DC Supply*.

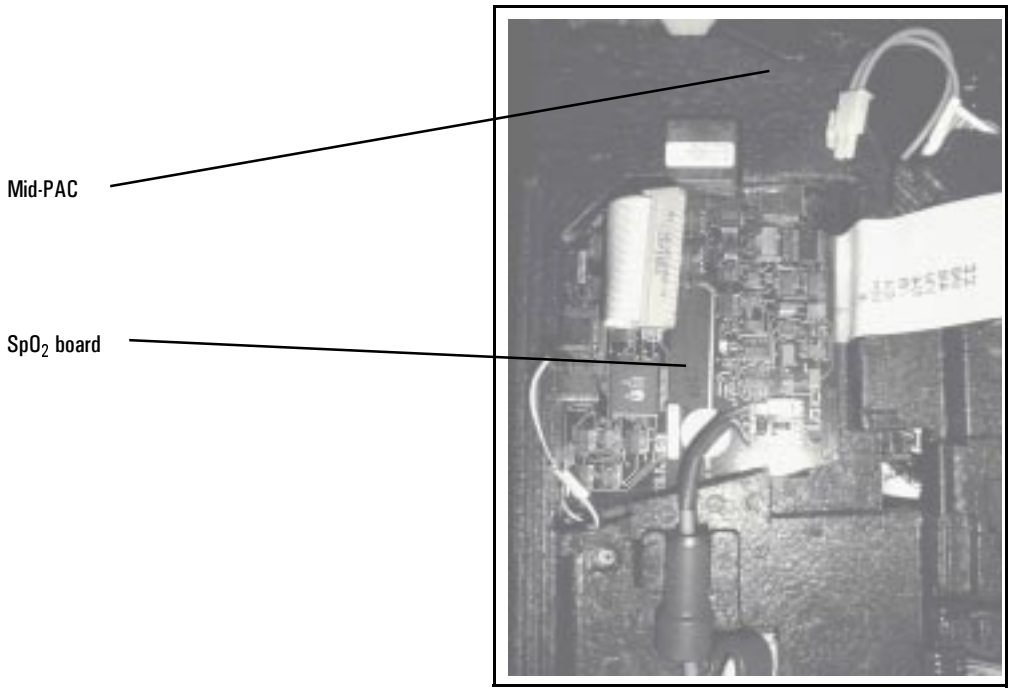
**2** Remove keypanel connector (J1).

**3** Remove the CRT deflector board cable from the CRT deflection board (J1) to free the mid-PAC.

**4** Remove $SpO_2$ / control board cable.

**5** Lift the mid-PAC and slide the $SpO_2$ board and shield (J12) through the opening as shown in Figure 5-19.

**Figure 5-19**




### $SpO_2$ Board Removal

**6** Guide the cables through the opening.

To replace the $SpO_2$ board, perform the procedure for *Removing the $SpO_2$ Board* in reverse order.

# Removing the Mid-PAC Assemblies

The Mid-PAC assembly is composed of the SpO2 PAC, Control PAC, the High Voltage PAC, the Patient Inductor PAC, the PCB PAC and the ECG PAC.

To remove the mid-PAC assemblies:

**1** Remove the ECG System board cable.

**2** Remove the SpO2 PAC.

**3** Remove the Control PAC.

**4** Remove the High Voltage PAC.

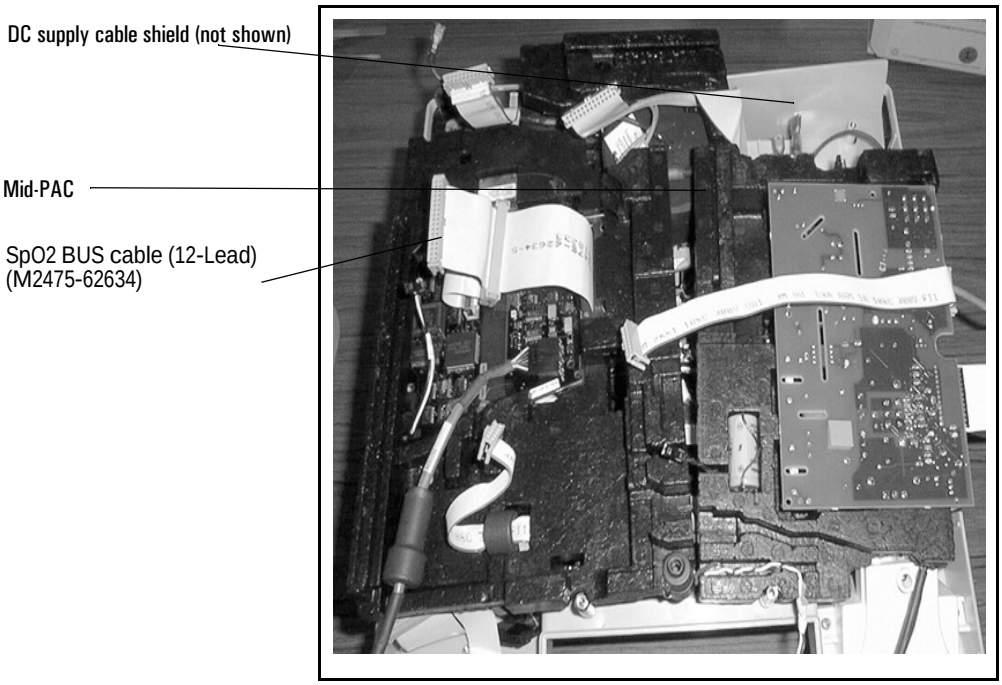
**5** Remove the Patient Inductor PAC.

**6** Remove the PCB PAC.

**7** Remove the ECG PAC.

**8** Remove and save the CRT deflector board shield.

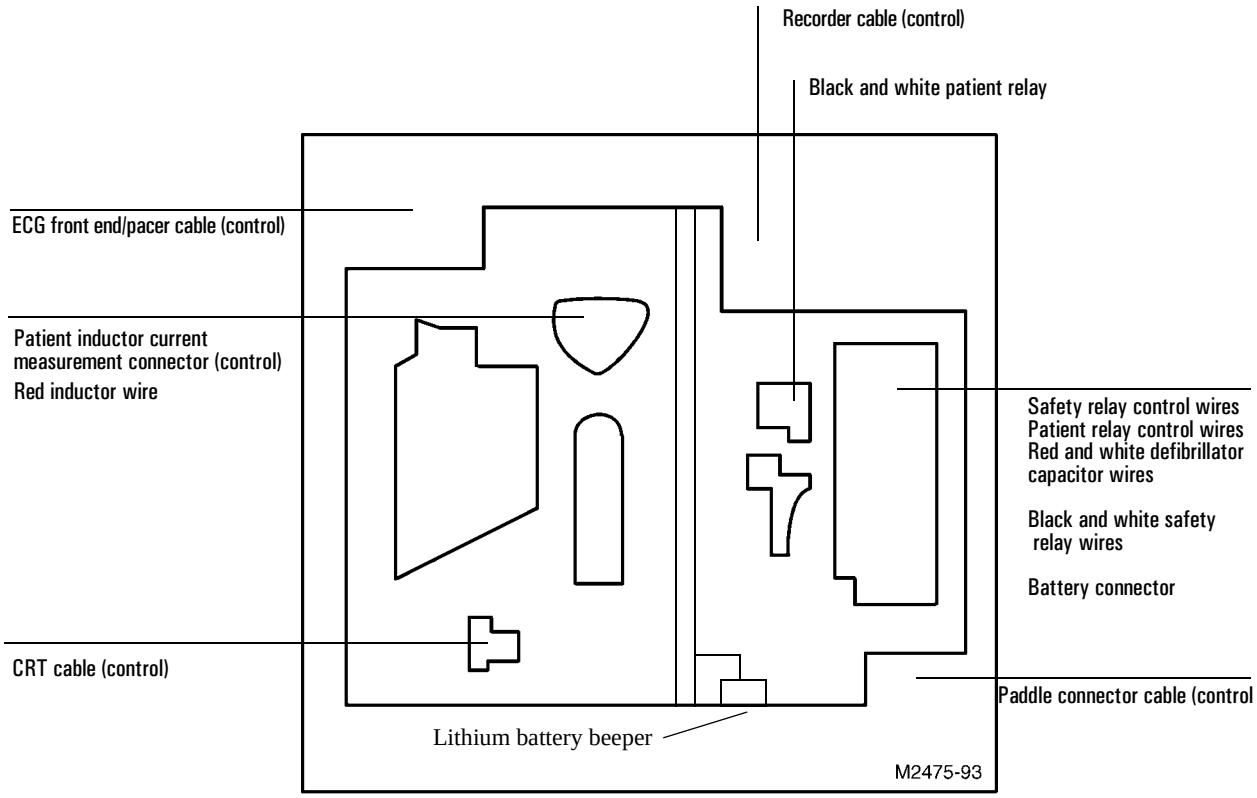
**Figure 5-20**




**Mid-PAC Removal**

To replace the mid-PAC, perform the procedure for *Removing the Mid-PAC* in reverse order. See Figure 5-21 for correct routing of cables and wires through the mid-PAC.

**Figure 5-21**




**Mid-PAC Cable/Wire Routing**

# Removing the Patient Inductor

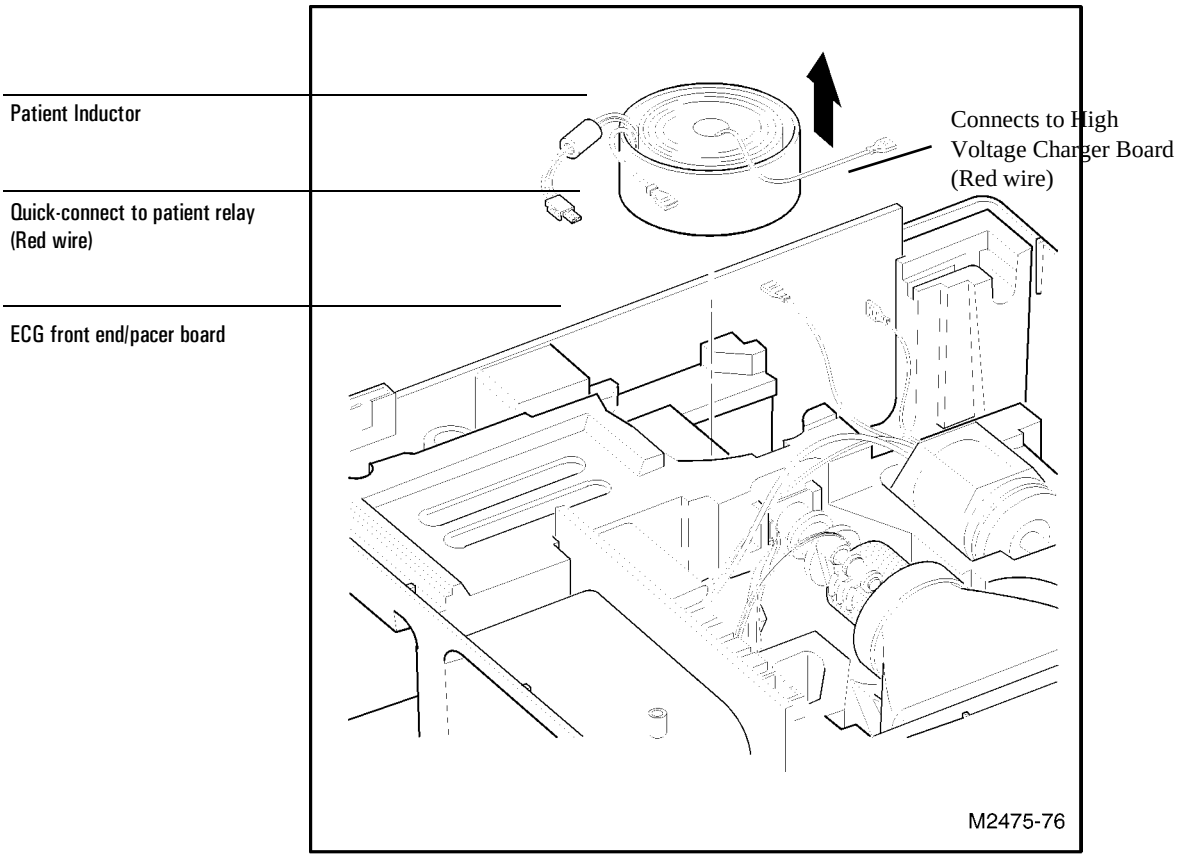
To remove the patient inductor:

**1** Remove the Patient Inductor PAC.

**2** Disconnect the quick-connect on the red wire going to the patient relay.

**3** Lift the patient inductor from its position in the Top Case PAC, as shown in Figure 5-22.

**Figure 5-22**


Patient Inductor
Quick-connect to patient relay (Red wire)
ECG front end/pacer board
Connects to High Voltage Charger Board (Red wire)
M2475-76

### Patient Inductor Removal

To replace the patient inductor, perform the procedure for *Removing the Patient Inductor* in reverse order. Be sure to align the raised nub on the outside of the inductor with the notch in the top case PAC.

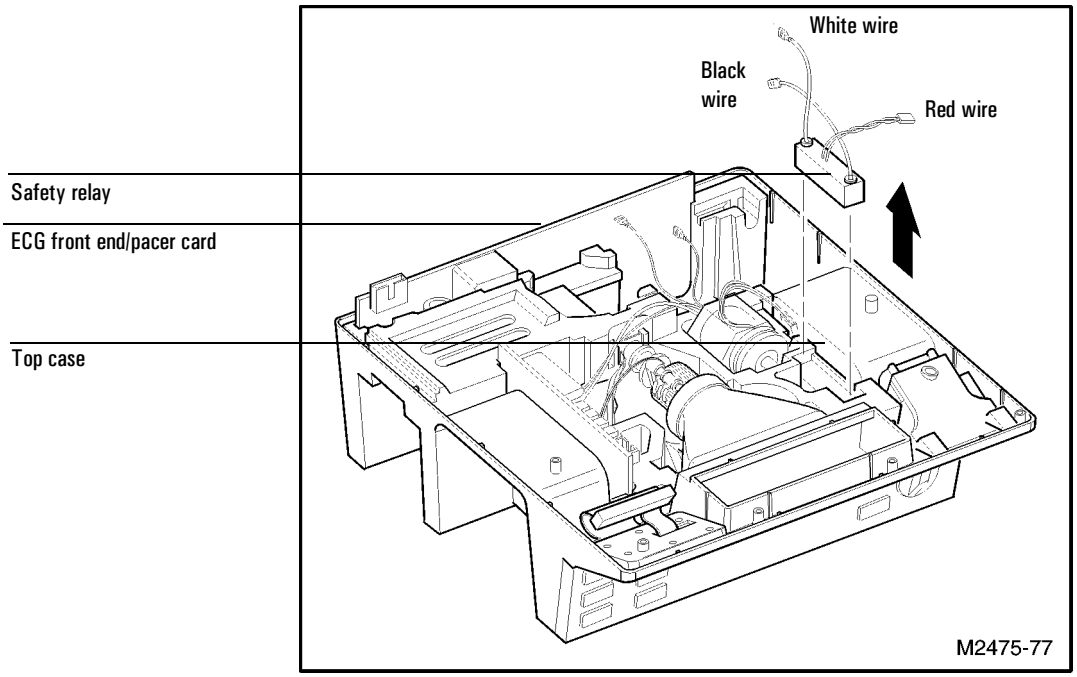
# Removing the Safety Relay

To remove the safety relay:

**1** Remove the Patient Inductor PAC.

**2** Lift the safety relay from its position in the HP-PAC as shown in Figure 5-23.

**Figure 5-23**




### Safety Relay Removal

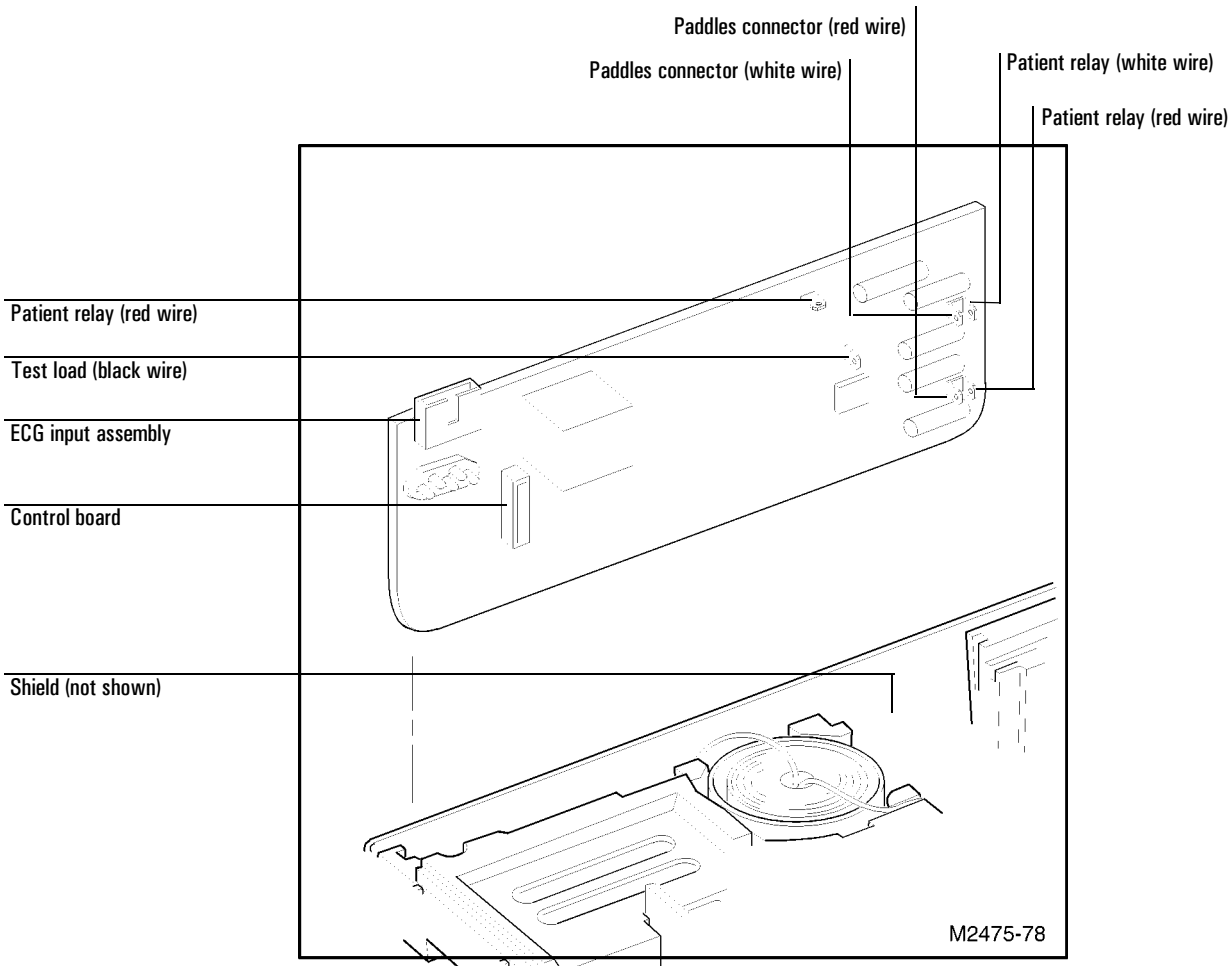
To replace the safety relay, perform the procedure for *Removing the Safety Relay* in reverse order.

# Removing the ECG Front End/Pacer Board

To remove the ECG front end/pacer board:

1. Perform the procedure for *Removing the Mid-PAC*.
2. Lift the ECG front end/pacer board half-way up from its position in the HP-PAC (Figure 5-24).
3. Remove the three quick-connects from the patient relay, also shown in Figure 5-24.

**Figure 5-24**




**ECG Front End/Pacer Board Removal**

**4** Disconnect the quick-connect from the test load.

**5** Disconnect the quick-connect from the paddles connector (two wires)

**6** Lift the ECG front end/pacer board from the HP-PAC.

To replace the ECG front end/pacer board, perform the procedure for *Removing the ECG/Front End Pacer Board* in reverse order.

# Removing the Patient Relay

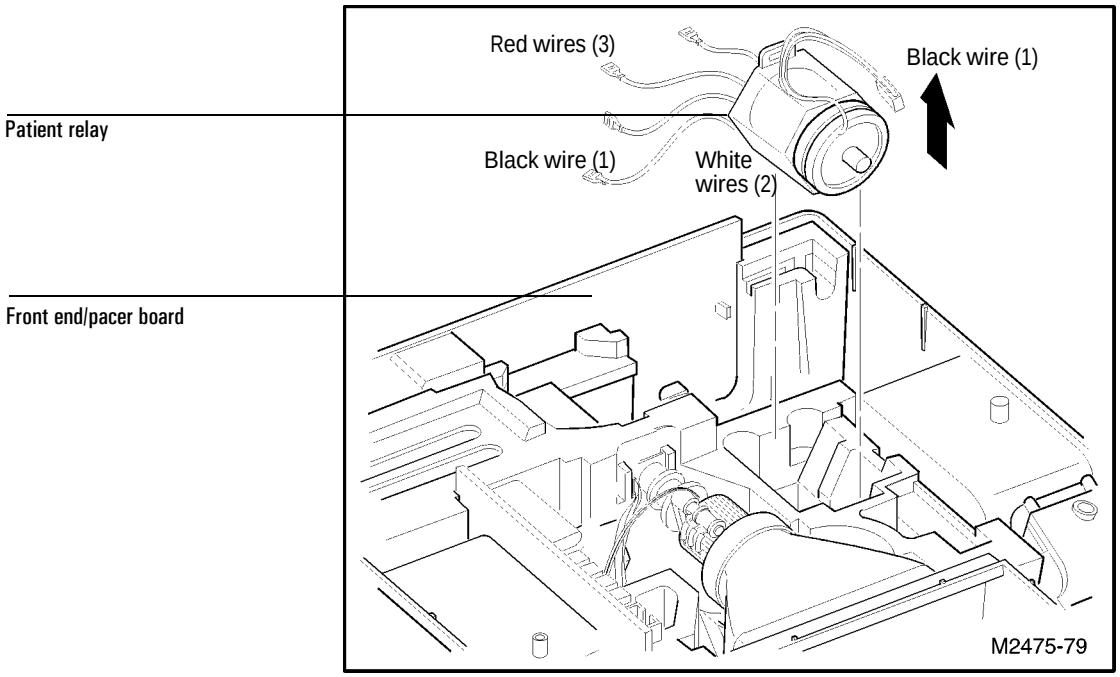
To remove the patient relay:

**1** Perform the procedure for *Removing the Mid-PAC*.

**2** Perform the procedure for *Removing the ECG/Front End Pacer Board*. Only steps 1-3 are necessary to remove the patient relay.

**3** Lift the patient relay from its position in the HP-PAC as shown in Figure 5-25.

**Figure 5-25**




**Patient Relay Removal**

To replace the patient relay, perform the procedure for *Removing the Patient Relay* in reverse order.

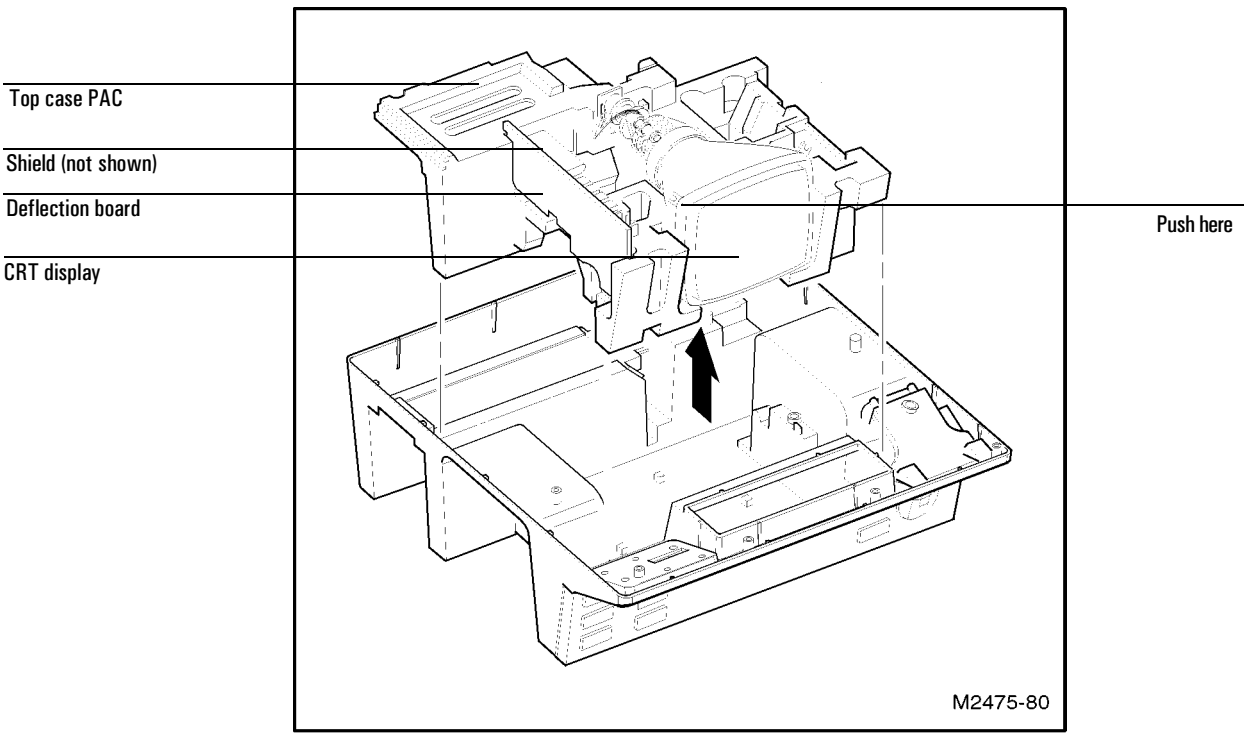
# Removing the CRT Assembly

To remove the CRT assembly:

**1** Perform the procedures for *Removing the Sp02 and High Voltage PAC Assemblies, Removing the Safety Relay* and *Removing the Patient Relay*.

**2** Lift the CRT and CRT deflection board with the top case PAC as a single unit, as shown in Figure 5-26. Push in on the CRT display to unsnap it from the opening in the top case.

**Figure 5-26**




**CRT Assembly Removal**

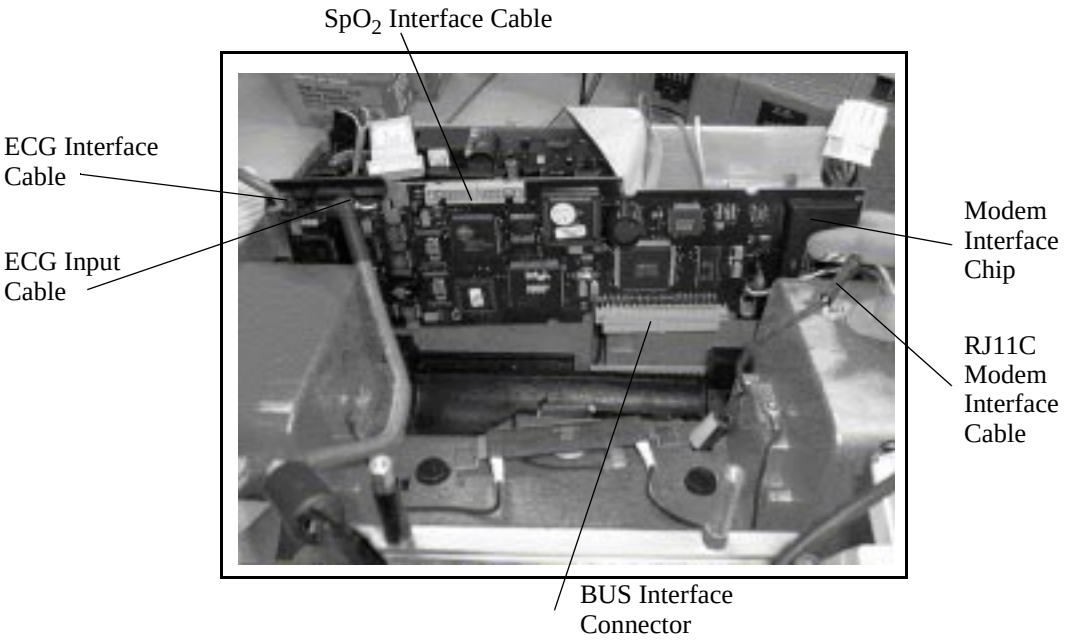
To replace the CRT assembly, perform the procedure for *Removing the CRT Assembly* in reverse order.

# Removing the ECG System Board

To remove the ECG System board:

1. Perform the procedures for *Removing the Sp02 and High Voltage PAC Assemblies* and *Removing the CRT Assembly*.
2. Remove the $SpO_2$ interface cable. See page 5-27.
3. Remove the ECG (12-Lead) interface cable.
4. Remove the ECG input cable.

**Figure 5-27**




**Removing the ECG System Board**

5. Remove the $SpO_2$ cable.
6. Remove the RJ11C modem interface cable (2 capacitors attached).
7. Loosen the BUS interface connector at the base of the ECG System board.
8. Lift the ECG System board up, away from the PAC assembly at the base of the unit.

**CAUTION**

Be sure that the cable routing, which contains cable ties, does not fall behind the ECG System board or under the power supply. Be sure that you route the ground wire to the

power supply underneath the ECG System board. Be sure that the cable from the relay to the inductor sits in the plastic channels or this cable could fall beneath the ECG System board.

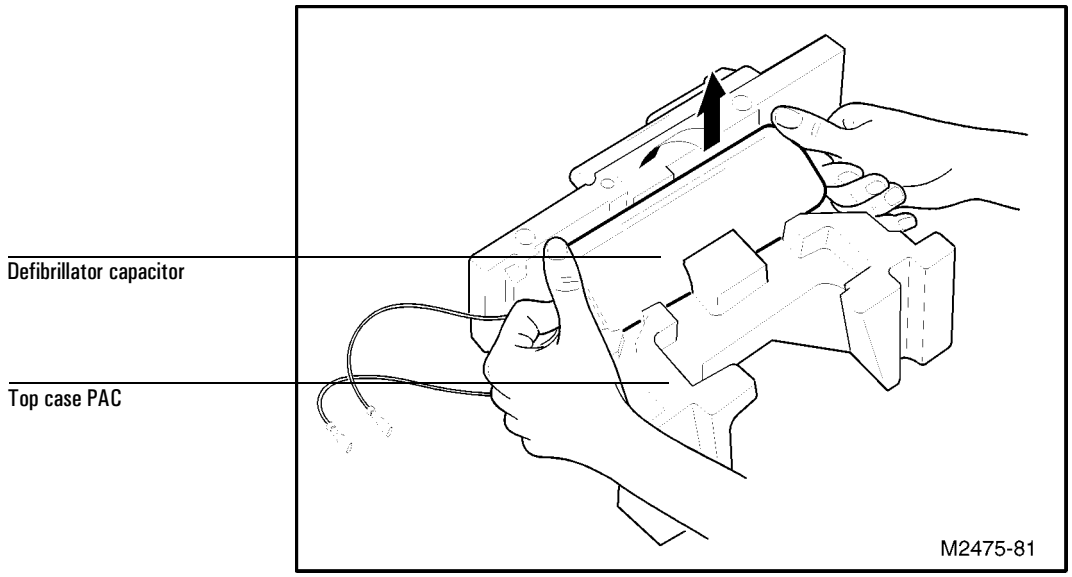
To replace the ECG System board, perform the procedure for *Removing the ECG System Board* in reverse order.

## Removing the Defibrillator Capacitor

To remove the defibrillator capacitor:

**1** Perform the procedure for *Removing the CRT Assembly*.

**Figure 5-28**




**Defibrillator Capacitor Removal and Replacement**

**2** Remove the defibrillator capacitor from the molded pocket in the HP-PAC.

To replace the defibrillator capacitor.

**1** Insert the defibrillator capacitor into the pocket of the HP-PAC with the wires feeding through (See Figure 5-28).

**2** Rotate the defibrillator capacitor into position.

**3** Dress the wires into the channel.

**4** Rotate the top case PAC so the defibrillator capacitor is facing down and replace it.

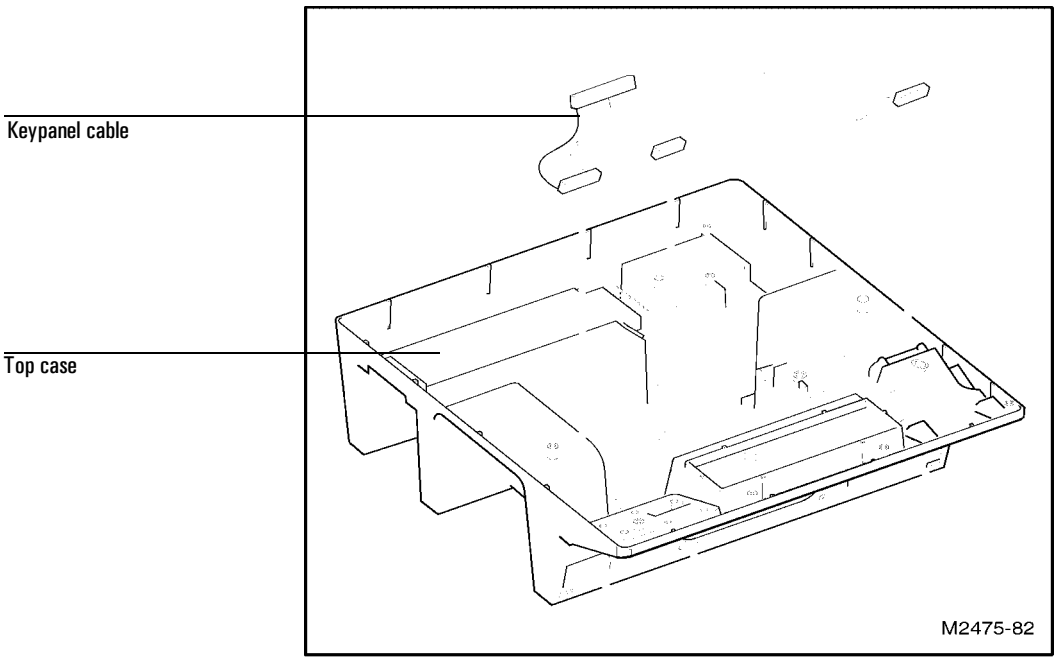
## Removing the Keypanel Cable

To remove the keypanel cable:

**1** Perform the procedure for *Removing the CRT Assembly*.

**2** Remove the keypanel cable from its position as shown in Figure 5-29.

**Figure 5-29**




**Keypanel Cable Removal**

To replace the keypanel cable, perform the procedure for *Removing the Keypanel Cable* in reverse order.

# Removing the Test Load Resistor

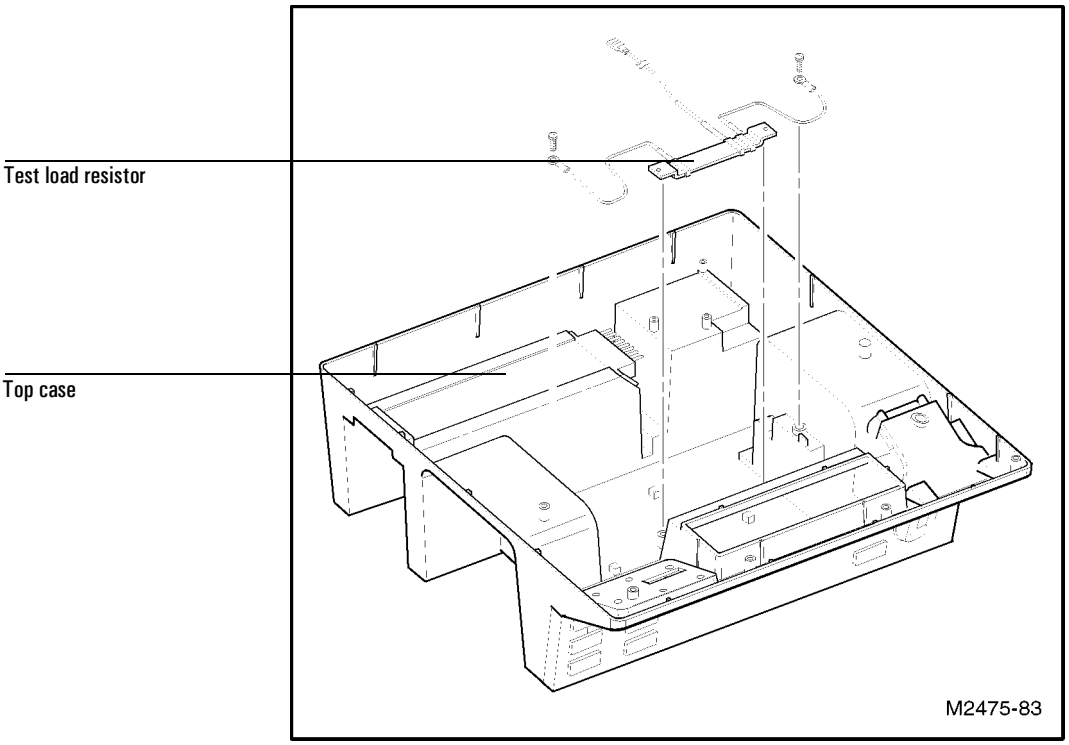
To remove the test load resistor:

**1** Perform the procedure for *Removing the CRT Assembly*.

**2** Lift the test load resistor from its position as shown in Figure 5-30.

**CAUTION** The test leads are fragile, so use care when handling them.

**Figure 5-30**




**Test Load Resistor Removal and Replacement**

To replace the test load resistor, perform the procedure for *Removing the Test Load Resistor* in reverse order.

# Adjusting the Internal Delivered Energy Calibration

Perform this calibration only when replacing a pre-tested control board, or patient inductor in the defibrillator, or when a user suspects that the reported delivered energy is incorrect.

Equipment required:

- Calibrated defibrillator test box. (50 Ω load ±1%, measurement of delivered energy ±2%).
- Insulated adjustment tool.

To calibrate the internal delivered energy measurement, perform the following steps:

**1** Calibrate the defibrillator capacitor by selecting the CALIBRATE DEFIB calibration procedure in the diagnostic service mode of the unit. Follow the instructions on the screen.

**2** Charge the defibrillator to 100 joules and discharge into the test box. Verify that the defibrillator delivered between 90 and 110 joules of energy into the test box.

Do not proceed if the defibrillator delivered less than 90 joules or greater than 110 joules. Instead refer to Chapter 4, Troubleshooting, for detailed troubleshooting information.

**3** Perform the procedures for *Removing the Battery Pack* and *Removing the Bottom Cover*.

**WARNING**

**Dangerous voltages are exposed when performing this procedure. Be certain not to touch the circuitry, wiring, or components while performing this procedure. This procedure is to be performed only by qualified service personnel.**

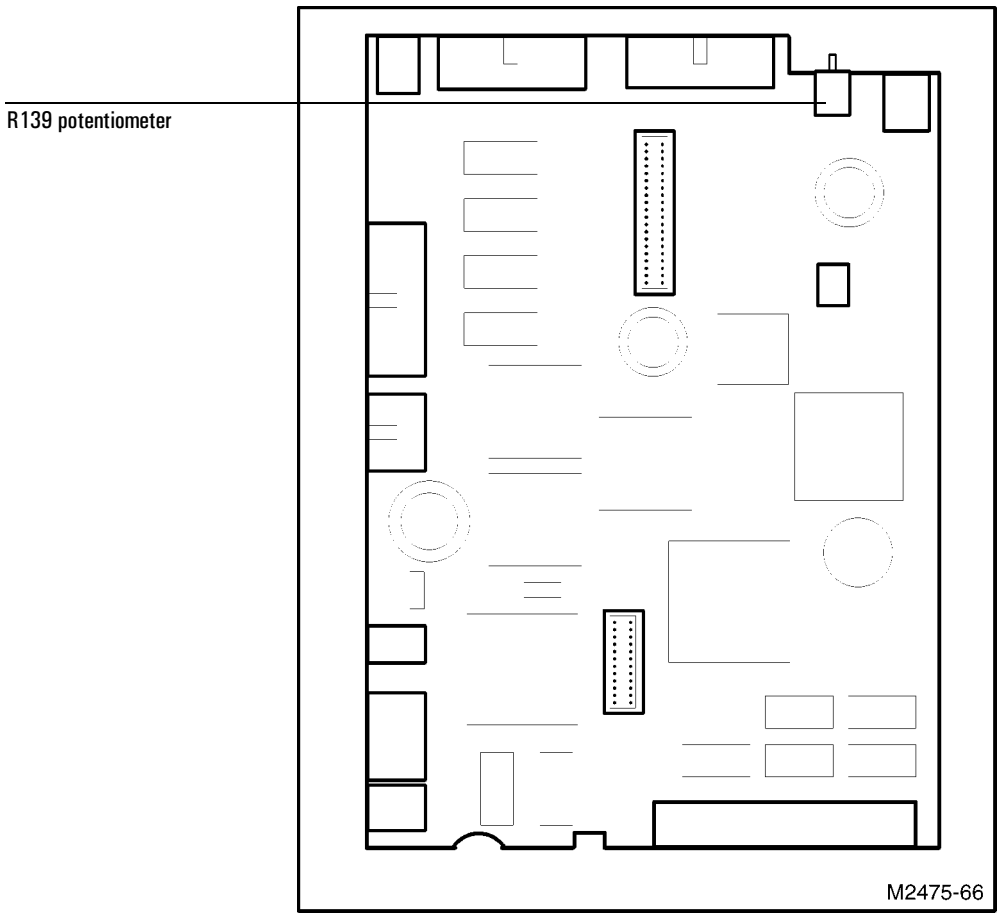
**4** Reinstall the battery.

**5** While pressing the (Sync) and (HR Alarm) keys, turn the Energy Select control to Monitor On.

**6** Press the (ECG Size) key to select `TEST DEFIB` on the screen. Then press the (Lead Select) key. The `TEST DEFIB` screen should now be displayed on the CRT.

**7** Locate the potentiometer R139 as shown in Figure 5-31.

**Figure 5-31**




**R139 Potentiometer Location**

**8** Attach the paddle set to the defibrillator connector.

**9** Charge the defibrillator to 100 joules and discharge into the defibrillator test box.

**10** Read the impedance measurement of the TEST DEFIB screen.

Example section of TEST DEFIB screen:

```
DELIVERED ENERGY:100

IMPEDANCE:50

PEAK CURRENT:29
```

Adjust R139 clockwise if the displayed impedance is greater than 50 Ω, counter-clockwise if the displayed impedance is less than 50 Ω. Repeat from step 10 until the impedance measurement reads 50 Ω.

**11** Turn the Energy Select control to **Off** (**Standby**).

**12** Remove the battery from the defibrillator.

**13** Replace the bottom cover.

**14** Turn the Energy Select control to the 100 joule position, and perform a 100 joule delivered energy test (Paddles in pockets). Verify that the recorder prints (`TEST 100J PASSED`).

This completes the Internal Delivered Energy Measurement adjustment procedure.

## Verifying Operation After Service

Refer to Chapter 3, **Performance Verification and Maintenance**, to verify operation after service.

# Theory of Operation

## Introduction

This chapter provides assembly level theory of operation for the HP CodeMaster 100 Portable Defibrillator/Monitor (M2475B) with integrated 12-Lead ECG option.

Additional theoretical information, following the information for the CodeMaster 100, is provided for the HP M2476B/M2477B NiCd Batteries, HP M2480B Battery Support System, HP M2478A DC Power Module and HP M2479A AC Power Module; since all of these are ‘instrument replaceable’ units, only a minimum of theory is supplied for each.

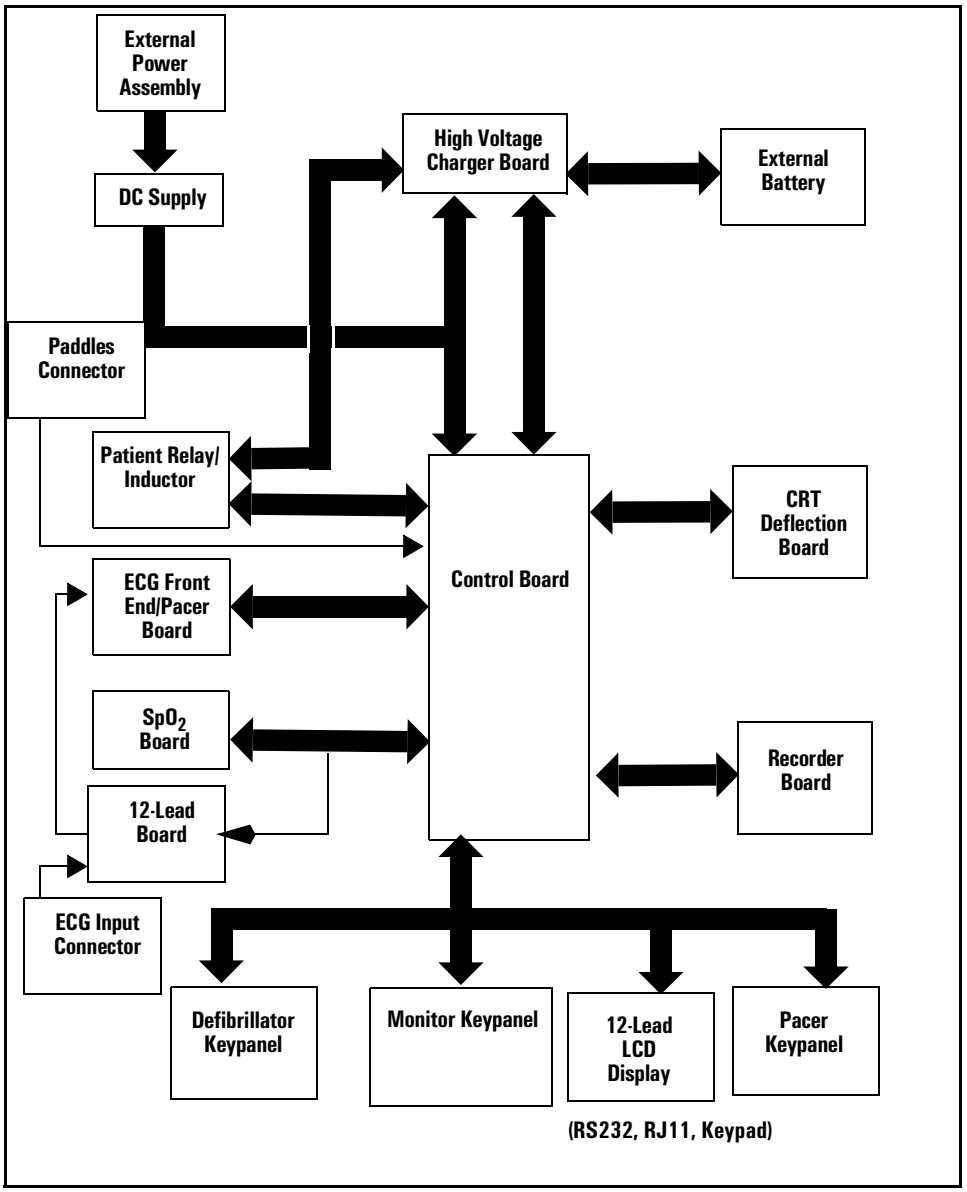
## M2475B CodeMaster 100 Portable Defibrillator/Monitor System Theory

Theory for the CodeMaster 100 is a discussion of the following major electronic assemblies:

- Control Board
- Internal DC Supply
- High Voltage Charger Board
- Patient Circuit
- CRT Deflection Board
- ECG Front End/Pacer Board
- Recorder Board
- $SpO_2$ (Pulse Oximeter) Board
- Defibrillator-Pacer Patient Connections
- Keypanels
- ECG System Board

These are the primary field-replaceable assemblies as shown in Figure 6-1, the CodeMaster 100 System Block Diagram. For a complete listing of parts available for field repair, refer to Chapter 7, *Parts Lists*.

**Figure 6-1**




**HP CodeMaster 100 System Block Diagram**

### Circuit References

Components are usually referred to by the component's function (such as the defibrillator processor). References more specific than that are to individual diagrams that accompany the text.

With a few exceptions, the only signal names used in this theory description are those that pass between the boards. Appendix A provides signal descriptions for each connector. Some signal names are prefixed with a letter that indicates what kind of signal it is. While this is not always true, you can usually assume the following:

- c Connector signals. These have been conditioned for EMI purposes.
- f Filtered signals. These signals have been low-pass-filtered to minimize the high frequency components that they would otherwise contain.
- n Active Low.
- p Pulsed signals (except for clocks, which usually have "clk" embedded in their names).

## Control Board

The control board provides the processing power to run the defibrillator and supplies a central interconnect for other parts of the unit. The following three processors are supported on the control board:

• 87C196KD (the defibrillator processor)

• 80960KA (the monitor processor)

• µPD77C25 (digital signal processor–DSP)

These processors are connected to one another and to peripheral devices through two CMOS gate arrays, the system gate array and the CRT/recorder gate array. Figure 6-2 shows the functional groupings and their basic interconnections.

The control board performs a variety of individual functions that fall into three major functional groups, each centered on one of the three processors. Other functions on the control board include the DC supply board and three analog functions.

### Defibrillator Processor Functional Group

The defibrillator processor handles defibrillation control, system monitoring, and the keyboard and indicator interface with the system gate array.

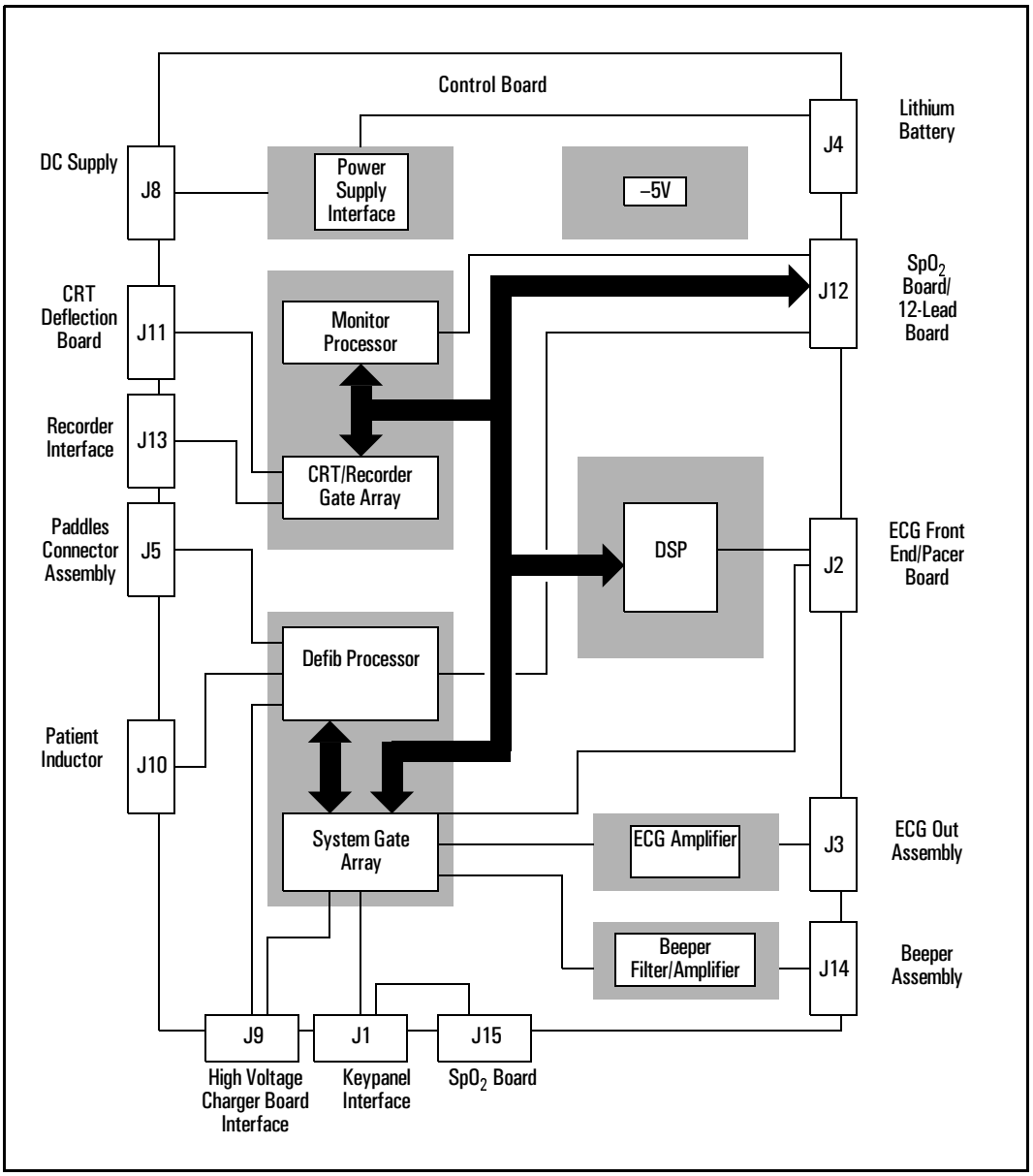
### Defibrillation Control

Defibrillation control includes the charging and discharging operations.

**Charging.** The defibrillator processor detects the closure of the paddles charge key, fnPADCHG, at one of the processor's direct analog inputs, or it detects the closure of the front panel charge key, fnCHARGEKEY, by reading its value from the system gate array. After a debounce time, the key closure is considered valid and the processor begins a charge operation. The level of charge is determined from the value of four bits from a grey-coded rotary Energy Select control (fENSEL 0, 1, 2, and 3). The level of change can also be read from the system gate array).

Before charging begins, the defibrillator processor instructs the system gate array to open the safety relay, which is located on the high voltage charger board. The system gate array asserts fOPNSFRLY (open safety relay), which commands the high voltage charger board to remove the 47 kΩ safety resistor that is normally across the defibrillator capacitor.

**Figure 6-2**




**Control Board Block Diagram**

A charge operation begins when the defibrillator processor instructs the system gate array to assert the logic signal fnCHGEN and give the analog signal fCHRATE a non- zero value. These signals go to the high voltage charger board, which begins charging at the specified rate. While charging, the defibrillator processor monitors the energy present in the defibrillator capacitor by sampling the capacitor voltage, fVCAP.

When the processor is satisfied that the proper energy is stored in the defibrillator capacitor, it turns the charger off by placing a zero value on the fCHRATE line, and de-asserting fCHGEN. As charge bleeds off the defibrillator capacitor, the processor will periodically request refresh charges from the charging circuitry. If the requested charge is lowered, the safety relay is used to bleed off charge to the lower level.

**Discharging.** When external pads are connected and both the Sternum and Apex Shock keys are closed, a shock request occurs that asserts fnDISCHGS and fnDISCHGA. These two signals are "NORed" to generate fHVDISCHG which is routed to both the defibrillator processor and the high voltage charger board (for redundancy purposes).

The defibrillator processor performs the shock operation by issuing a shock request command to the system gate array. When this happens, the system gate array takes over. It begins a waiting period (approximately 1 msec.) that allows the processors to prepare to be reset. When the waiting period is over, all processors are reset. The system gate array then asserts fPRDRV, which when combined with fHVDISCHG, closes the patient relay. Once the patient relay is closed, only fPRDRV true is required to keep it closed. The safety relay is also closed (fOPNSFRLY is de-asserted) when the fPRDRV line is asserted.

When the shock reset time is over (approximately 80 msec from shock initiation), the system gate array releases all processors from reset. All processors then perform post-shock initialization and resynchronize communication paths. At 300 msec from shock initiation, the defibrillator processor opens the patient relay, thus terminating the shock sequence

### System Monitoring

The defibrillator processor monitors a variety of system functions. Some of these are read directly by the processor at its analog inputs, while others are first preselected using an analog multiplexer. The direct measurements are:

| | |
|---|---|
| **Capacitor voltage** | A sample of the voltage across the defibrillator capacitor (VCAP). Used to determine the energy stored in the capacitor. One volt at the A/D equals 1144 volts at the defibrillator capacitor. |
| **Printhead temperature** | Reads the value of fTSENSE, an analog signal generated by a temperature sensor on the recorder. Used to vary the duty cycle for printhead write in response to changes in printhead temperature. |
| **Head resistance** | The recorder board encodes printhead resistance into a voltage (fCAL). The defibrillator processor converts fCAL to a digital signal used by the monitor processor to set the duty cycle for printhead writes. |
| **Paddles identification** | The defibrillator processor reads the voltage value on the fPADID line to determine the type of paddles connected to the unit. Table 6-1 lists the voltage levels for the paddles types. |

**Table 6-1 PADID Voltage Value vs. Paddles Type**

| fPADID | Paddles Type |
|---|---|
| < 0.5 V | Internal Paddles. |
| ≥0.5, < 3 V | External Paddles. |
| ≥3.0, < 4 V | External Pads. |
| ≥4.0 V | None. |

The multiplexed measurements are:

**Peak current** The defibrillator processor reads the value on the SIPEAK line, which is a sample of the peak discharge current delivered to a patient. One volt at the A/D converter indicates 20.5 amperes of peak current.

**Pacer current** The pacer current is sampled on the ECG front end/pacer board and delivered to the control board on the fPACMES line.

**Supply voltages** The control board monitors the following voltages:
- Battery (VBATT)
- +12 V (12V)
- +5 V (5V)
- +VDC (VDC2)

**Defibrillator status** The defibrillator processor reads fDEFIBSTAT, an analog signal generated by the high voltage charger board to provide status information. Normally, the status is "good" when fDEFIBSTAT is >2.5 V, and "error" when ≤2.5 V. Immediately following a shock (while the patient relay is still closed) status is "good" when fDEFIBSTAT is <1.0 V, "error" when ≥1.0 V.

### Keyboard and Indicator Interface

The defibrillator processor performs most of the keyboard and indicator functions through the system gate array. For keyboard functions, this is implemented with a parallel register set. The defibrillator processor debounces keys, which are then saved in the system gate array. In the system gate array, both the defibrillator and monitor processors can access the debounced key registers.

Similarly, output drive for the LED indicators comes from a parallel port (controlled by the defibrillator processor). These outputs drive emitter followers, which provide the current drive required by the LEDs.

All key lines are filtered for EMI. The filters also provide some protection to the inputs of the gate array.

QRS volume control is accomplished using the two digital signals fVOLDEC (decrement volume) and fVOLINC (increment volume) which are input to HSI0 and HSI11 of the 87C196KD.

The Energy Select control is treated differently. It uses a 1 kΩ pull-up resistor to provide more current for switch contact reliability.

## The Monitor Processor Functional Group

The monitor processor (an 80960KA processor) handles central processing, and with the CRT/recorder gate array, display control and recorder control. The monitor processor also handles the interface with the $SpO_2$ board.

### Central Processing

The main processing power of the system consists of the monitor processor, its decoding and demultiplexing logic, ROM, and RAM. The CRT/recorder gate array provides clocks and various control signals to these parts. The monitor processor operates at ~ 8.2 MHz (clk2 equals 16.4 MHz).

System ROM consists of two 128K×16 devices which are socketed; system RAM consists of four 128K×8 devices. System RAM and the RAM interface to the processor are backed up by battery to ensure that data is not lost during power-up or power-down. The real-time clock circuitry is also backed up by the battery.

The monitor processor communicates with the defibrillator processor and the real-time clock through the system gate array. The system gate array also provides four levels of monitor processor interrupts.

### Display Control

The CRT/recorder gate array interfaces the monitor processor to the display. The gate array generates the necessary strobes to support a fixed-plane 256Kx4 VRAM and a moving-plane 256Kx4 VRAM, and provides video and sync information for the CRT. Both full-bright and half-bright information is provided to the CRT. The gate array also enables the monitor processor to randomly read and write VRAM.

### Recorder Control

The CRT/recorder gate array also interfaces the recorder to the monitor processor. The recorder requires four 384-bit serial data streams every 5 ms. Because of the very high overhead that would be required for the processor to do this directly, the CRT/recorder gate array converts this to 48 32-bit accesses (performed via DMA) from system RAM. The CRT/recorder gate array also generates the appropriate motor control strobes to operate the recorder stepper motor. These motor control strobes are pulse-width modulated at 32 kHz to reduce motor current consumption.

To maximize printhead life and reliability, an electronic power switch turns off the supply voltage when the recorder is not in use. The power switch is a FET with very low on-resistance and is turned on or off by processor command.

### Interface to the $SpO_2$ Board/12-Lead Board

The monitor processor interfaces to the $SpO_2$ and 12-Lead boards through J12. This interface consists of an 8-bit address/data bus with associated strobes for direction and timing control. The interface includes two reset lines, nERAWRST and nPRST, from the control board, and three interrupts. Supply voltages available are +5 V and +12 V from the main power supply, and +DIGBACKUP from the digital backup supply on the control board.

## Digital Signal Processor (DSP)

The uPD77C25 digital signal processor (DSP) handles digital signal processing of ECG front end information. The DSP and its supporting logic interface to the ECG front end serially using the signals fFESI, fFESO, fnFESENL, and fnFESENP. The DSP interfaces to the monitor processor through the CRT/recorder gate array.

## Power Supply Interface

The power supply interface consists of four parts:

• Digital backup supply

• Power failure detector

• Switch A control

• LED drivers

### Digital Backup Supply

The signals VDC2 and VBATT are diode-ORed to form +VBACKUP, which passes through a low current regulator to generate a +5 V supply, +DIGBACKUP. The +DIGBACKUP signal powers the On/Off circuitry and VRAM.

### Power Failure Detector

When the +5 V supply voltage drops below +4.65 V, this circuit generates nPF, a signal that interrupts both processors via the system gate array, and ≈4.8 ms later produces nRAWRST, the basic reset signal.

### Switch A Control

Switch A is a solid-state FET switch in the power supply that connects the battery to VDC. When the defibrillator is connected to external power, Switch A opens to allow battery charging. When the defibrillator is not connected to external power and the unit is turned on, Switch A closes to enable the battery to power the unit. The Switch A control circuit generates fSWADRIVE, the drive signal for Switch A. fSWADRIVE closes Switch A when the ON, nSHUTDOWN, and nACON lines are high.

The Switch A control circuit includes part of the mechanism that shuts down the unit when the battery gets too low. One minute after the defibrillator processor detects that battery voltage has become too low, it instructs the system gate array to set a flip-flop in the Switch A control circuit. This turns off SWADRIVE to open Switch A and disconnects the battery. Turning the Energy Select control off and then on, or replacing the battery, restores operation for at least another one minute until the low battery condition again forces the unit to shut down.

### Low Battery Warning

The unit always shuts down whenever the battery voltage falls below a predetermined shut off threshold. The low battery warning function provides at least 10 minutes of warning to the user before the unit shuts down. The low battery warning message is displayed whenever the available charge on the Benchmarq charge monitor IC (located in the battery pack) falls below a predetermined charge threshold. In the event that the Benchmarq charge monitor IC fails, a secondary circuit located in the unit detects the drop in battery voltage below a predetermined level and generates a low battery warning message. The device provides a warning tone 60 seconds prior to shutdown.

### LED Drivers

One driver provides power to the battery charging LED when external power is on and the battery is installed; the other driver provides power to the external power-on LED when external power is on.

## Miscellaneous Analog Functions

Miscellaneous analog functions performed on the control board are:

- I-peak measurement — A voltage winding in the patient inductor samples discharge current. The I-peak measurement circuit integrates and peak-detects the sample to produce SIPEAK.

- –5 V generation — a voltage inverter converts +5 V to the low-current –5 V used by some of the operational amplifiers.

- ECG amplification — an AC-coupled voltage doubler that converts a CMOS-level pulse-width-modulated signal from the defibrillator gate array into the 10 V peak-to-peak (+5 V to –5 V) signal required by the 1000:1 ECG output.

• Beeper filtering/amplification — filters and amplifies the TONE signal that comes from the system gate array. Provides a 12 V peak-to-peak signal to drive the beeper.

## Power-Up/Down Processes

The following describes how the control board performs the powering-up and powering-down processes. It is assumed that a charged battery is installed. In either case, +VBACKUP is about +12 V and +DIGBACKUP is at +5 V.

### OFF State

When the Energy Select control is in the off position, the fnON signal line is pulled high. This tells the power supply to not generate any of its regulated voltages. Consequently, +5 V is near ground and the power-fail detector holds nPF) (the power fail signal) low and generates nRAWRST. nRAWRST is the reset signal that generates most of the other reset signals.

### Power-Up

When the Energy Select control is moved from its off position, fnON is shorted to ground. This tells the power supply to start generating its regulated voltages. When the +5 V supply reaches +4.72V, nPF goes high. About 316 ms later, nRAWRST also goes high.

nRAWRST going high tells the gate arrays to begin generating clocks and to start their exit from reset processes. When all the resets are released, the monitor processor performs its boot-up and tries to establish communications with the defibrillator processor via the system gate array.

The monitor processor does a self-check when it comes out of reset. When first released from reset, the monitor processor drives the nFAILURE line low. It then performs a series of internal checks. If the results are satisfactory, it releases the nFAILURE line. The processor then fetches the first eight words from memory (ROM) and performs a checksum on the results of the fetch. If the checksum is correct, the processor continues. If not, the nFAILURE line is again driven low and the processor halts operation. By watching the nFAILURE line as the processor comes out of reset, you can determine whether the processor is functioning internally and whether its connection to ROM is functioning.

### Power-Down

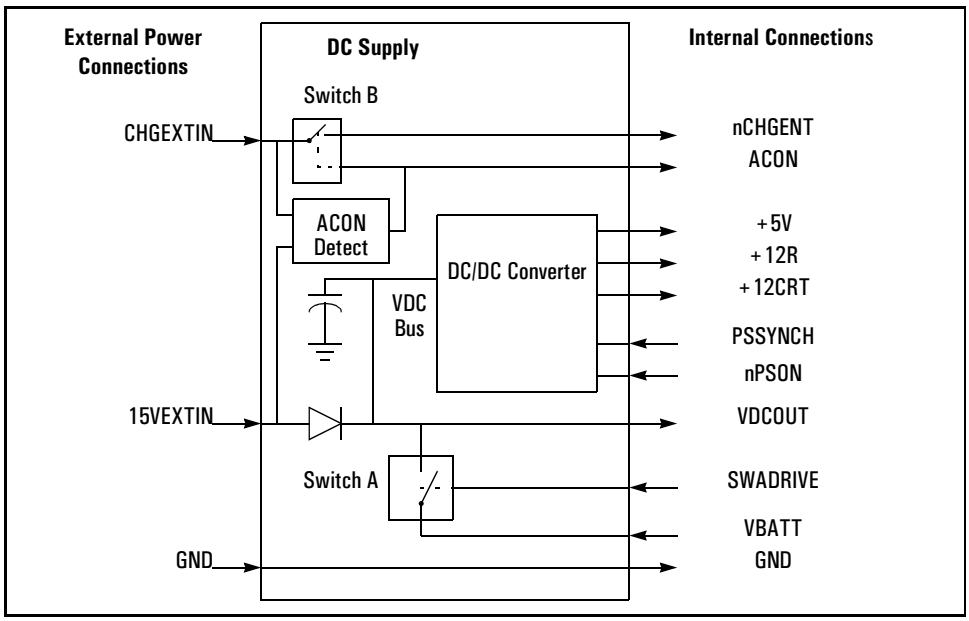
A power-down sequence is initiated by the power-failure detector. When the Energy Select control is moved to its off position or the +5 V supply drops below +4.65 V, the power-failure detector asserts nPF. This signal is routed to the system gate array, which then drives a power- fail interrupt to both the monitor and defibrillator processors. These interrupts tell the processors that they have 2 ms of power to accomplish any tasks that must be performed before they shut down.
4 ms after nPF occurs, nRAWRST is asserted.

# Internal DC Supply

This circuit converts the unregulated voltage on the VDC bus to three regulated voltage outputs called +5V, +12R, and +12CRT. The DC/DC converter, illustrated in Figure 6-3, is controlled by the PSON input and it is synchronized with the PSSYNCH input.

| | |
|---|---|
| ACON Detect | This circuit detects whether or not the 15VEXTIN external power input is present, and drives the ACON output to indicate whether external power is present or not. It is also used to control Switch B. |
| Switch A | This circuit is used to connect the VDC bus to the VBATT input. It is controlled by the SWADRIVE input signal. |
| Switch B | This circuit is used to connect CHGEXTIN to CHGEXTOUT if the 15EXTIN is within specifications. It is controlled by ACON. Switch B is closed if ACON is high. |

**Figure 6-3**




**DC Supply Module**

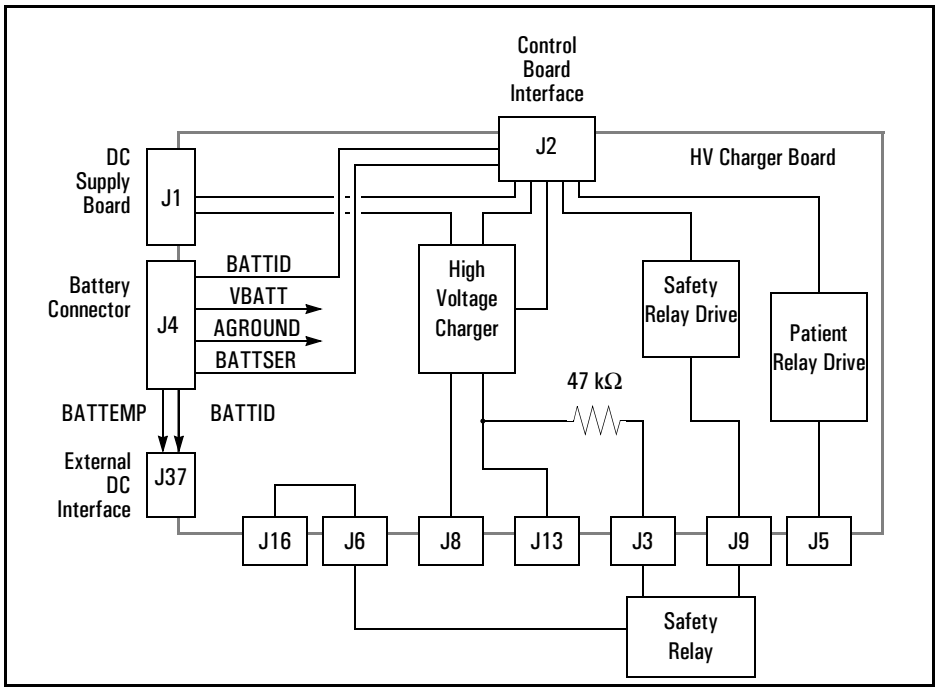
# High Voltage Charger Board

The following circuits make up the high voltage charger board:

- Battery connector
- Safety relay drive
- Patient relay drive
- High voltage charger

These circuits are shown in Figure 6-4.

**Figure 6-4**




**High Voltage Charger Board Block Diagram**

## Battery Connector

The battery connector connects the battery to the defibrillator. Power as well as battery I/O signals are routed to the high voltage charger board via J4. Battery voltage is then routed through the high voltage charger board to the power supply via connector J1. The BATTEMP and BATTID signals are routed through J37 to the external DC connector.

## Safety Relay Drive

The safety relay is normally closed and opens when control signal OPNSFRLY is true. As described in ‘Charging’ under the *Control Board* functions presented earlier in this chapter, this relay must open before the defibrillator capacitor can charge. When a defibrillation discharge occurs, the safety relay closes simultaneously with or up to 10 ms before the patient relay closes. The safety relay circuit then disarms the capacitor through an open paddles discharge.

## Patient Relay Drive

The patient relay switches high voltage to allow a defibrillator shock. For this to occur, both shock switches must be pressed to assert the signal DISCHRG, *and* the defibrillator processor must issue the shock command PRDRV (patient relay drive), which activates the patient relay. The defibrillator processor monitors the status of the discharge control circuitry by reading fDEFIBSTAT. The defibrillator processor can then display the appropriate error message in case of a fault. Error messages are explained in Chapter 4, *Troubleshooting*.

## High Voltage Charger

The high voltage charging circuit charges the defibrillator capacitor by means of a variable frequency, high-voltage flyback DC/DC converter. When the charging circuit is at room temperature and powered by a fully charged battery, “fast charge” occurs. In this mode the defibrillator can charge to 360 joules in under five seconds. The charging of the defibrillator capacitor is electrically isolated from grounded portions of the unit.

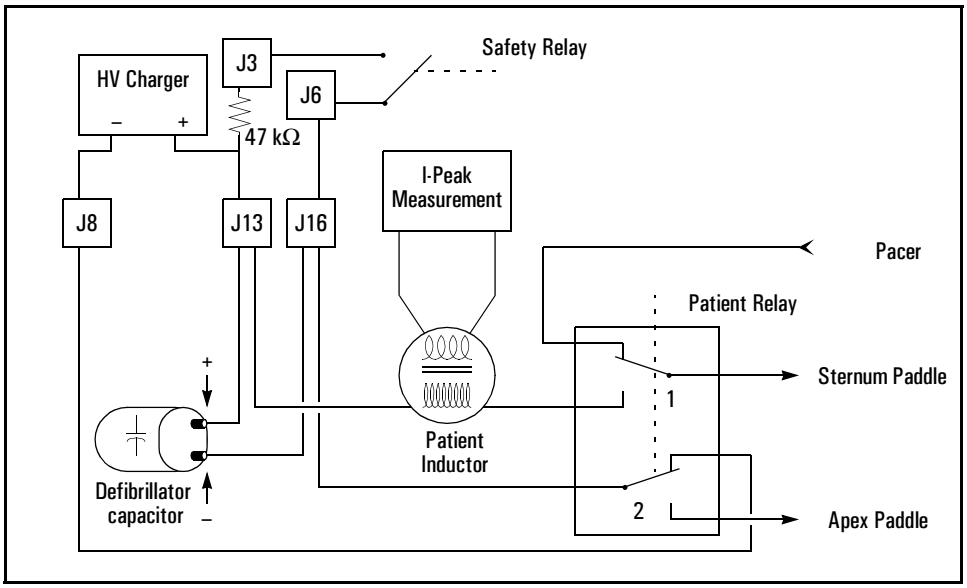
A charge begins when the signals OPNSFRLY, nCHGEN, and CHRATE are asserted. When the defibrillator capacitor reaches the proper energy setting, the defibrillator processor de-asserts the signals nCHGEN, and CHRATE to stop the charge.

# Patient Circuit

The patient circuit shown in Figure 6-5 consists of the following components:

- Defibrillator capacitor (35 μF, 5.1 kV)
- Patient inductor/I-peak transformer (50 mH, 11 Ω)
- Patient relay (double-pole, double-throw mechanical relay)
- Coil cords, connectors, and discharge paddles
- Safety relay (single-pole, single-throw mechanical relay)
- Patient load (either a patient or the internal 50 Ω test load resistor)

**Figure 6-5**




**Patient Circuit Block Diagram**

The defibrillator capacitor, patient inductor, and patient load form a series-resonant RLC circuit with a critical damping load resistance of 63 Ω. For a nominal patient load of 50 Ω, the discharge waveform is a slightly underdamped sinusoidal waveform.

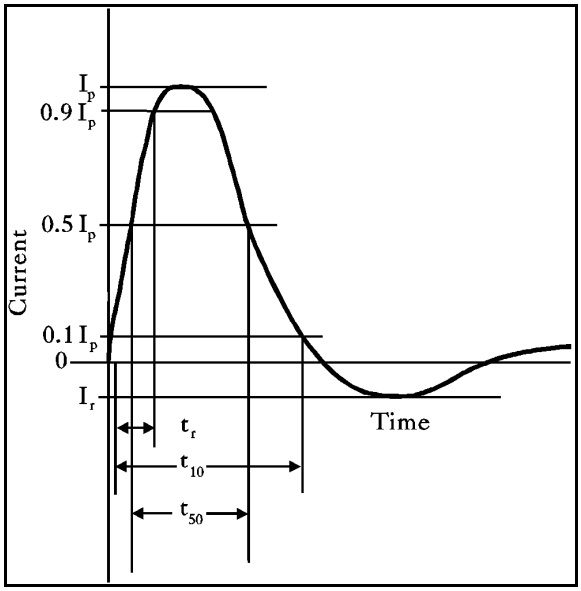
The defibrillator capacitor is charged up by the high voltage charger to the voltage required for any of the various energy settings, which range from 2 to 360 Joules (actual voltage on the defibrillator capacitor ranges from 325 V and 5300 V). This capacitor is then discharged through the patient inductor and the patient relay into the patient load.

During a shock, the patient relay isolates the patient circuit and capacitor from one side of the pacer circuit to prevent the pacer from absorbing energy from the delivered pulse, and isolates the high voltage charger from the capacitor to protect the charger from reverse polarity during waveform undershoot. The waveform characteristics of the pulse delivered through resistive loads of 25, 50 and 100 Ω is shown in Figure 6-6 and Table 6-2.

The patient inductor has a secondary winding that develops a current during discharge. This current is integrated and peak-detected on the control charger board to determine the peak discharge current, Ipeak. The coil cords carry the discharge current to the paddles and patient load, and also carry control signals to and from the paddles. The coil cords contain shielding to lower the RFI sensitivity of the high voltage discharge wires so they can also be used as low-noise sensing wires for the paddles ECG circuit on the ECG front end/pacer board.

The safety relay slowly discharges the capacitor when its energy is not needed but still present (i.e. aborted shock). This circuit also bleeds off part of the charge if the user selects an energy setting, the defibrillator charges to that setting, and then the user selects a lower energy setting.

**Figure 6-6**




**Damped Sinusoidal Waveform Parameters**

**Table 6-2** **Specifications for Damped Sinusoidal Output Waveforms**

| | Local Resistance | | |
|---|---|---|---|
| **Waveform Parameter** | **25 Ohms** | **50 Ohms** | **100 Ohms** |
| $I_p$ (amperes) | $96\alpha \geq I_p \geq 55\alpha$ | $66\alpha \geq I_p \geq 45\alpha$ | $46\alpha \geq I_p \geq 25\alpha$ |
| $I_r$ (amperes) | $38\alpha \geq \lvert I_r \rvert \geq 0.0$ | $18\alpha \geq \lvert I_r \rvert \geq 0.0$ | $4.0\alpha \geq \lvert I_r \rvert \geq 0.0$ |
| $t_r$ (ms) | $1.60 \geq t_r \geq 0.50$ | $1.42 \geq t_r \geq 0.40$ | $1.25 \geq t_r \geq 0.30$ |
| $t_{50}$ (ms) | $4.60 \geq t_{50} \geq 2.0$ | $4.17 \geq t_{50} \geq 2.10$ | $6.40 \geq t_{50} \geq 2.30$ |
| $t_{10}$ (ms) | $6.90 \geq t_{10} \geq 3.0$ | $9.20 \geq t_{10} \geq 3.10$ | $19.60 \geq t_{10} \geq 4.00$ |

$I_p$ Peak current of the waveform

$|I_r|$ Absolute value of the reverse current of the waveform

$\alpha$ $\sqrt{\frac{E}{360}}$ and E is the selected energy that would be delivered to a 50-ohm resistive load

$t_r$ 10% to 90% risetime of the first lobe of the current waveform

$t_{50}$ Waveform width associated with the 50 percentage points of the first lobe of the current waveform

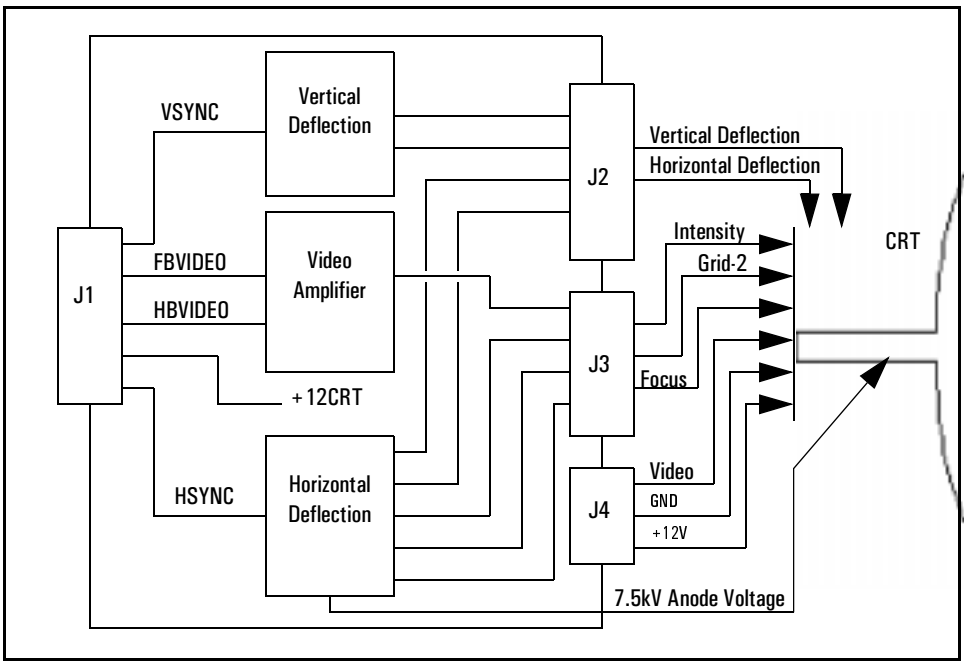
$t_{10}$ Waveform width associated with the 10 percentage points of the first lobe of the current waveform

## CRT Deflection Board

The CRT deflection board shown in Figure 6-7 performs these functions:

- Vertical deflection
- Horizontal deflection
- Video amplification
- CRT bias voltage generation

**Figure 6-7**




**CRT Deflection Board Block Diagram**

Signals entering the CRT deflection board from the control board are GND, VSYNC, VIDEO, CRT12V, and HSYNC.

The CRT displays information using a raster pattern. Total usable raster area is 832 dots horizontal, 256 dots vertical. Table 6-3 lists the specifications for the CRT.

**Table 6-3 CRT Specifications**

| Characteristic | Specification |
|---|---|
| Screen Size | 140 mm Diagonal |
| Deflection Method | Magnetic |
| Deflection Angles | Diagonal - 70 Degrees |
| | Horizontal - 66 Degrees |
| | Vertical - 45 Degrees |
| Phosphor | P43 (Yellow-Green) |
| Heater | 75 mA, 12 V (Typical) |

Control signals to drive the CRT come from the CRT/recorder gate array on the control board. Table 6-4 lists the control signal specifications:

**Table 6-4 Control Signal Specifications**

| | |
|---|---|
| **Vertical Deflection** | |
| Frequency | 57.1 Hz |
| Period | 17.5 ms |
| Blanking Time | 1.5 ms |
| Vertical Sync | 750 us (Active High) |
| **Horizontal Deflection** | |
| Frequency | 16.0 kHz |
| Period | 62.5 us |
| Blanking Time | 11.7 us |
| Horizontal Sync | 11.7 us (Active Low) |
| **Video** | |
| Dot Time | 61 ns (Active Low) |

## Vertical Deflection

Vertical deflection is accomplished by running a linear current ramp through the vertical coil on the CRT yoke. The Vertical Sync (VS) signal from the CRT controller generates the vertical deflection for the CRT.

## Horizontal Deflection

The Horizontal Sync (HS) and CRT bias voltages are generated when HS drives the flyback transformer, which provides supply voltages and horizontal deflection. Horizontal centering must be accomplished using the external magnets on the CRT yoke assembly. Horizontal width is adjusted with a series inductor, also built into the yoke assembly.

The following supply voltages are created for use in biasing the CRT:

| | |
|---|---|
| +28 V | Video amplifier and Vertical retrace |
| -39 V | Intensity (adjustable) |
| 300 V | Grid 2 bias |
| 300 V | Focus (adjustable) |
| 7.5 kV | Anode Voltage |

## Video

Two levels of video are presented to the CRT: full-bright and half-bright. Half- bright video is used for text, while full-bright video is used for ECG data. The beam is at full brightness when the video output to the CRT is 0 V, at half brightness when the video output is 4.3 V, and off when the video output is 28 V.

# 12-Lead LCD Display

The following components make up the 12-Lead LCD display:

• Liquid Crystal Display (LCD)

• Row Driver

• Column Driver

• M Circuit

• DC/DC Converter

• Temp Comp and Bias Circuit

• Back Light On/Off

• LED backlight

## Row Driver

The row driver circuits drive the row electrodes of the LCD display based upon the YD, DF, LOAD and M circuit inputs.

## Column Driver

The column driver circuits drive the column electrodes of the LCD display based upon the D0-D3, DF, LOAD, CP and M circuit inputs.

## M Circuit

The M circuit selects the proper voltage levels sequentially from the six levels available to generate the LCD drive waveforms and frame inversion in the Row and Column drivers.

## DC/DC Converter

The DC/DC converter converts the +5 volt input to a negative voltage for the LCD bias circuit.

### Temp Comp and Bias Circuit

The Temp Comp and Bias Circuit provides the temperature compensation of the contrast for the LCD display. The bias circuit divides the negative supply from the DC/DC converter into 6 voltage levels for the row and column drivers to generate the LCD waveforms.

### LED Backlight

The LED backlight is an array of 16 LED devices powered from the +5 supply which illuminates the LCD from the back.

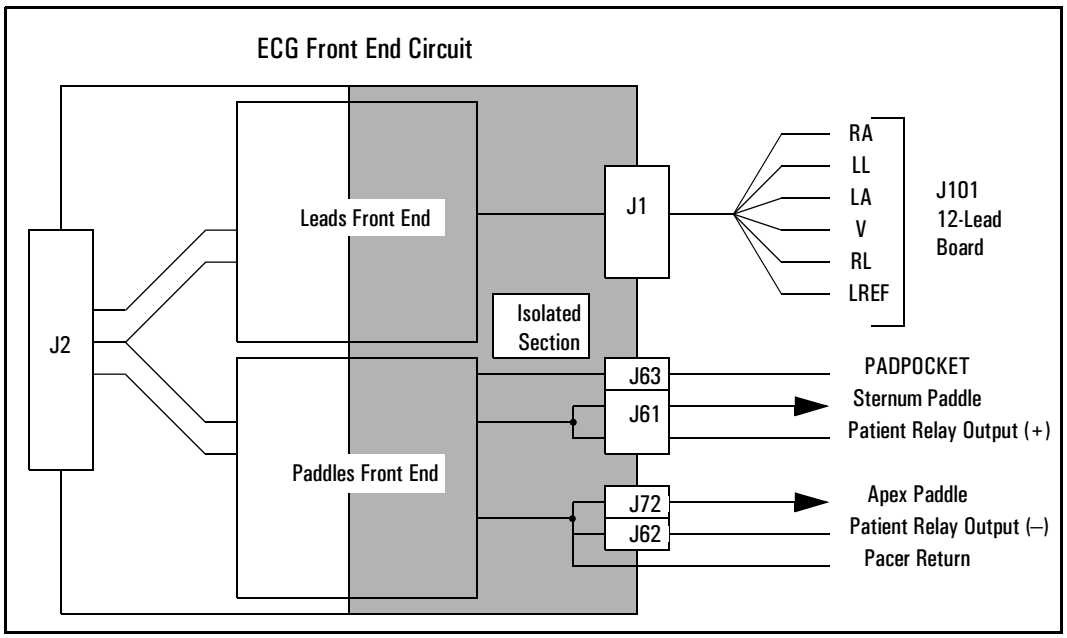
## ECG Front End/Pacer Board

The ECG front end and pacer board circuits are located on this board.

### ECG Front End Circuit

Two separate and isolated front ends constitute the ECG front end circuit as shown in the block diagram in Figure 6-8. The first is a two-wire paddles ECG amplifier, and the second is a five-wire leads front end. The paddles front end operation is nearly identical to the leads front end operation. The design for both front ends is based on a Hewlett-Packard custom front-end IC. The paddles front end also includes functions for paddles-in-pocket and pre-shock impedance (also called paddles contact impedance or PCI).

**Figure 6-8**




**ECG Front End Block Diagram**

Both front ends communicate with the Digital Signal Processor (DSP) located on the control board. The DSP processes the digitized data from both front ends simultaneously and provides data to the monitor processor.

### Front End Power Supplies

Each of the front ends has its own isolated power supply. The supply for the leads front end is enabled when the FELEN signal is true; the supply for the paddles front end is enabled when the FEPEN signal is true. A forward converter, which is clocked by FEPWRCLK, generates isolated power for the two front ends. The output of the converter is regulated to +5 V. The supply also provides a 2.5 V reference for use in biasing the front end IC.

### Leads Input Protection

The leads are connected to the five input channels of the IC through a breakdown device (neon bulb) and a 3-pole LPF. The neon bulb is used as defibrillator overload protection (current is limited by a 1 kΩ resistor in the lead set). The remaining voltage is dropped across 75 kΩ and the internal protection diodes of the IC.

### Paddles Input Protection

The paddles inputs are subjected to defibrillator shocks, and therefore are designed to meet 8 kV breakdown from paddle-to-paddle. 100 kΩ high-voltage resistors in series with the ECG input limit the current sufficiently to allow the input protection diodes on the front end IC to handle the current. As part of the preshock impedance path, series resistors and capacitors are also high voltage devices. External diode clamps are added to this path, routing current away from the front end IC.

### Cal Pulse

Internally generated signals allow for self-test and gain calibration.

### Data Communication

Clocks and data are transmitted through opto-isolators across the isolation boundary. Data transmitted to the front end IC include control parameters such as gain, Right Leg Drive lead, etc. Digitized ECG data and status information is transmitted from the front end IC to the DSP chip on the control board.

### Pre-Discharge Impedance

An indication of paddles contact is given on the bar graph located on the external paddles (PCI). patient impedance (at 32 kHz) is measured by the paddles front end IC. This measured impedance value is used by the defibrillator processor to determine the drive level to the PCI bar graph on the sternum paddle.

### Paddles in Pocket

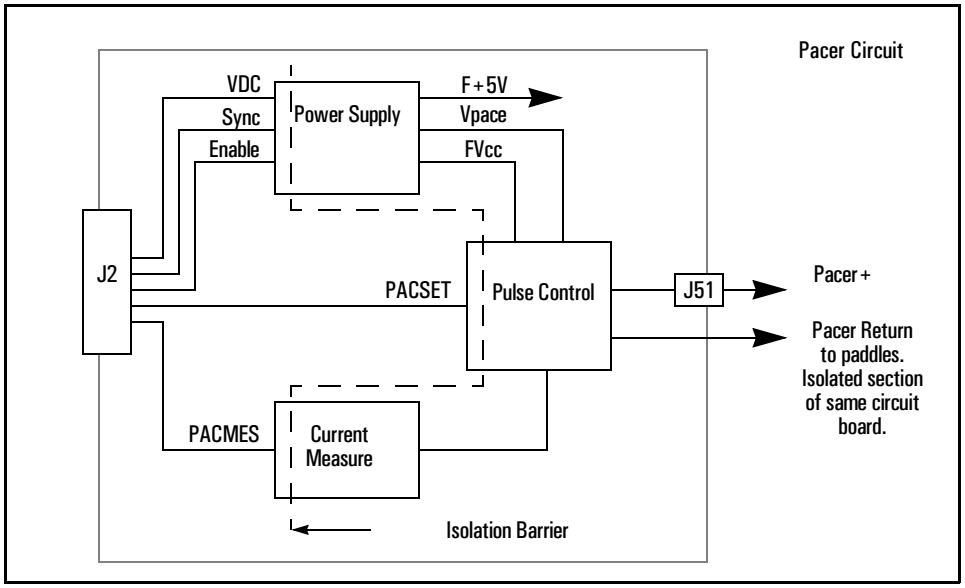
To detect paddles in pocket, the paddles front end IC applies a signal to the center tap of the 50Ω test load resistor (the center-tap is connected to the paddles front end through connector J63). If this signal is detected on the Vapex and Vsternum inputs, the front end IC signals that the paddles are in the pockets.

## Pacer Circuit

The pacer circuit shown in Figure 6-9 generates pacer output to these specifications:

| | |
|---|---|
| Current Pulse | 20 ms +0% -25% |
| Amplitude | 10 mA to 200 mA, 10 mA to 50 mA: ±5 mA,<br>50 mA to 200 mA: ±10% |
| Rate | 40 to 180 pulses-per-minute ±1.5%<br>at each setting |

**Figure 6-9**




**Pacer Circuit Block Diagram**

### Pacer Board Power Supply

An isolated supply on the pacer board generates+ 5 V and +12 V power (F+5V and FVcc, respectively) to run the pacer electronics, and the 120 V pacer voltage (Vpace).

### Pulse Control

Pace pulse amplitude is set by a pulse width modulated signal from the system gate array. The duty cycle for the PWM signal is 13.5% to 90%, corresponding to a pulse amplitude from 30 mA to 200 mA respectively.

The pulse train from the system gate array is 20 ms long. When the pulse train starts, it begins the current pulse. When the pulse train ends, the current pulse ends.

### Pacer Current

Pacer current is measured and routed back to an A/D converter (internal to the defibrillator processor). Then, delivered pacer current can be compared to the expected set current.

### Patient Isolation

The pacer is a patient connected device, therefore adequate patient isolation must exist for pacer circuitry. A high voltage isolation barrier is formed by a power transformer in the power supply, and opto-couplers in the pulse control and current measuring circuits.

## Recorder Board

The recorder board provides power and control signals from the CRT/recorder gate array to the printhead and motor.

The printhead control signals pass through the board to the printhead. These signals provide the data, clock (4 MHz), latch, and strobe for the printhead. Other signals provide status of the printhead to the gate array such as printhead temperature and resistance, which are required for print quality. An optical sensor in the recorder provides the status of the recorder door and recorder paper (if the door is open or the paper is out the `CHECK RECORDER` message appears on the monitor).

# $SpO_2$ Board

The arterial oxygen saturation measurement ($SpO_2$) is based upon the principle of pulse oximetry, whereby arterial blood flow is detected optically though the tissue. As the blood becomes more heavily oxygenated the transmittance of red light increases. An algorithm comparing the transmittance of red and infra-red light provides an indication of oxygen saturation. The pulse oximeter circuit design eliminates the effects of absorption from tissue, bone, and venous blood by isolating the pulsatile component of the signal.

To measure the $SpO_2$ level a pulse oximetry sensor is placed on the patient that holds two LEDs and a photo diode. The LEDs emit red and infra-red light against one side of the patient's finger (the nose or toe are other sites sometimes used). The photo diode along the opposite side of the patient's finger registers small changes in the transmittance of light through the finger. The sensor is connected to the device via a cable and a connector. The output from the sensor goes directly to the pulse oximeter parameter board ($SpO_2$ board).

The $SpO_2$ board, shown the block diagram in Figure 6-10, is divided into two distinct circuits: electrically floating and electrically grounded. These circuits are connected by two high voltage optocouplers for data transfer, and a power transformer for power transfer to the floating circuit.

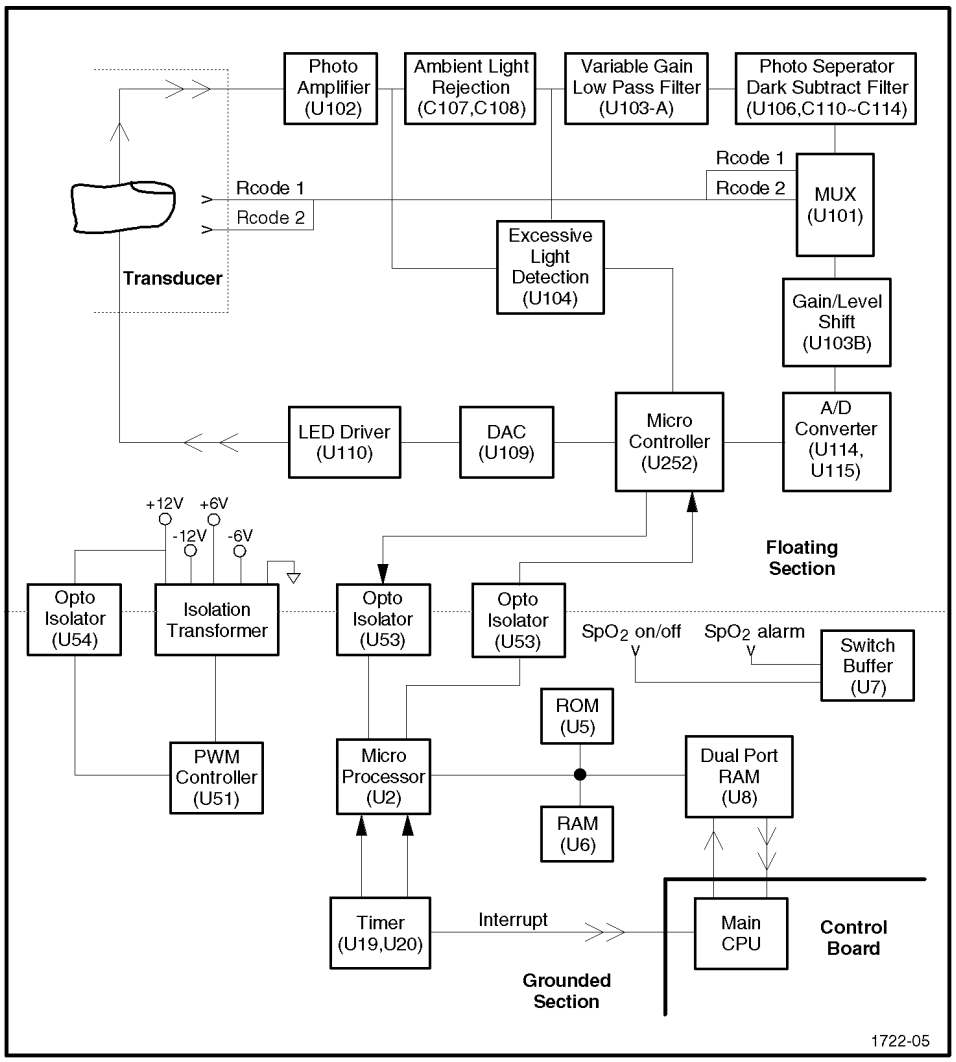
## Floating Section

The floating section has two functions:

- Enables accurate reading of light transmittance by removing noise and compensating for ambient light in the pulse train.

- Drives the red and infra-red LEDs in the transducer cable.

**Figure 6-10**




**$SpO_2$ Board Block Diagram**

The LEDs are driven and the photo diode signal is sampled in four discrete phases:

1 **Dark phase** - During this phase neither red nor infra-red LEDs are lit and ambient light is measured.

2 **Red phase** - In the red phase the red LED is lit and the transmittance of the light through the finger is measured.

3 **Infra-red phase** - In the infra-red phase the infra-red LED is lit, and transmittance measured.

4 **Pleth Phase** - During this phase the infra-red LED is lit, and transmittance measured. This signal is used to drive the pulse indicator bar on the CodeMaster display.

Consecutive frames of these four phases are repeated 375 times per second. Both the lighting of the LEDs and the sampling of the signal from the photo diode is controlled by the microcontroller (U252).

### Photo Amplifier

The photo amplifier (U102) converts current (output from the photo diode) to voltage. Low pass filtering for electrosurgical unit (ESU) filtering and noise reduction is also done in this stage.

### Excessive Light Detection

A comparator (U104) monitors the output of the photo amplifier, checking for excessive light. Excessive light could cause amplifiers to operate in a non-linear range, giving erroneous readings.

### Ambient Light Rejection

A two-pole high pass filter (C107, C108) rejects signals from ambient light.

### Amplification

The op amp, U103A, is used as a variable gain amplifier. It amplifies the detected light signal to an optimal amplitude for the A/D converter. U103B applies additional gain and level shifting, centering the signal for the A/D converter.

### Phase Separation - Dark Subtract Filter

A series of switched low pass filters (U106, C110 - C114) are used to separate the four phases of light (dark, red, infra-red, and pleth). The sequence of operation is software controlled. The four phase sequence is described as follows:

1 **Dark phase** - The switch governing the dark capacitor (C110, C111) is closed. Switches governing the red, infra-red, and pleth capacitors (C112, C113, and C114 respectively) are open. The dark capacitor is charged by the pulse resulting from the ambient light reading.

2 **Red phase** - The switch governing the “Red” capacitor is closed. All other switches are open. Capacitor “Red” is charged by the pulse resulting from the red LED reading. The pulse received by amplifier U103B is equivalent to the value of (ambient light + red light) minus (ambient light).

3 **Infra-red phase** - The switch governing the “Infra-Red” capacitor is closed. All other switches are open. Capacitor “Infra-Red” is charged by the pulse resulting from the infrared LED reading. The pulse received by amplifier U103B is equivalent to the value of (ambient light + infrared light) minus (ambient light).

4 **Pleth phase** - The switch governing the “Infra-Red” capacitor is closed. All other switches are open. Capacitor “Infra-Red” is charged by the pulse resulting from the infrared LED reading. The pulse received by amplifier U103B is equivalent to the value of (ambient light + infrared light) minus (ambient light).

### Multiplexer

A multiplexer (U101) is used to switch signals into the A/D converter. The signals are:

1 Received light signal.

2 Rcode1.

3 Rcode2.

Rcode1 and Rcode2 are resistors in the transducer. The voltage across these resistors is measured to determine that the transducer is properly connected, and the type of transducer connected.

### A/D Converter

A 16 bit successive approximation A/D converter is formed from a 16 bit DAC (U114), a comparator (U115), and a microprocessor controller (U252).

### LED Drivers

The LEDs are driven by a controlled current source (U110). The two functions provided by the LED driver are:

1 The LEDs must be lit in their correct sequence, to produce the four phases of the pulse frame.

2 The LEDs must be lit to an intensity that optimizes the signal to noise ratio of the received light signal.

An 8 bit DAC (U109) controls the LED driver (U110), using positive and negative pulses of 0 - 125 mA, which trigger the red and infra-red LEDs respectively. The intensity of illumination is determined by the current of this triggering pulse.

## Grounded Section

The grounded section of the $SpO_2$ option board is completely digital. It is essentially a dedicated microcomputer, and among other tasks, performs the following:

**1** Communicates with the floating section through the two opto-isolators.

**2** Calculation of the $SpO_2$ saturation percentage and pulse rate.

**3** Processes any error conditions (cable off, light interference, etc.)

**4** Communicates with the main CPU board in CodeMaster via the option slot on the control board.

Dedicated timer circuits control the timing of events. In addition, the signals from the front panel keys $SpO_2$ ON and $SpO_2$ ALARM are routed through the $SpO_2$ option board to the control board.

### Microprocessor System

The processor is a Hitachi 6303, using external RAM and ROM. The processor runs on a 2mS cycle, which is controlled by the timer circuits (U19 and U20). Once every 20mS the processor writes data to the Dual Port Ram (U8).

### Communication

An interrupt is generated every 20 mS, indicating to the control board that data is available to be read. At this time, the switch buffer (U7) is read to check for any key presses, and $SpO_2$ data ($SpO_2$%, PR, error conditions) are read from the dual port RAM.

### Power Supply

The power supply is designed to provide isolated power to the floating circuitry. The circuit is a fly back topology, with feedback though an opto isolator (U54) to control the pulse with modulator. The transformer includes taps to generate ±12 V and ±6 V. In addition, linear regulators exist on the floating side to generate +5 V and -5.2 V.

### Patient Isolation

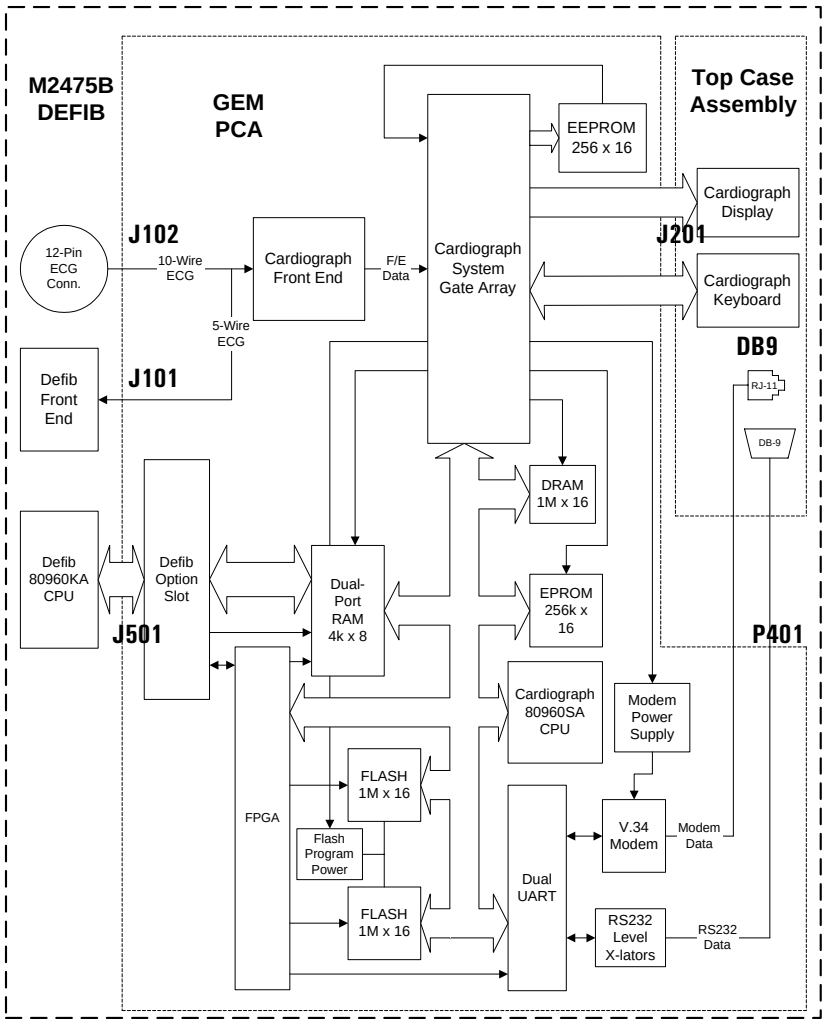
To ensure the safety of the patient the applied part is isolated from ground by optocouplers and a transformer. In addition, a mylar shield is used to isolate the floating circuitry from the CRT frame.

# Keypanels

The defibrillator keypanel, the monitor keypanel, 12-Lead keypanel and the pacer keypanel contain the push-button switches and LED indicators that provide the hardware user interface. The Energy Select control connects to the main keypanel.

# 12-Lead Board

**Figure 6-11**




**12-Lead Board Block Diagram**

## ECG Signal Path

The 12-lead and defibrillator ECG front-end (F/E) electronics share a common 12-pin ECG connector. ECG signals from the patient are routed via either a 10-wire, 3-wire or 5-wire lead set to the connector. Inside the defibrillator, a 10-wire ECG cable then routes the input signals to the ECG System Printed Circuit Assembly (PCA). A 5-wire ECG jumper cable routes a subset of the signals to the defibrillator front end PCA.

The defibrillator F/E processes 3 or 5 wires of the input ECG signals for independent analysis and display on the CRT. This F/E also provides the right-leg drive signal for both the defibrillator and 12-lead electronics.

The 12-lead front end converts the 10-wire low level input signals into digital F/E data. This data is transferred as serial data across the patient isolation barrier to the 12-lead system gate array.

## 12-Lead option (#C90) Central Processing Unit

The 12-Lead 80960SA CPU is the same microprocessor used in the PageWriter 200i. It processes F/E data from the 12-Lead system gate array, as well as interfacing with a number of peripheral devices.

One of the two non-volatile 1M x 16 FLASH memory devices contains the CPU's program instructions. The other FLASH is used for storage of processed patient ECG reports. An on-board flash program power supply allows program memory to be downloaded via the external RS232 port or the CPU to store patient ECG reports. The FLASH memory devices are the same devices used in the Storage and Transmission Option (#A05) of the PageWriter 200i.

The CPU accesses several other memory devices. The 256k x 16 EPROM acts as a boot ROM for system start-up. The 1M x 16 DRAM is the system's random access memory. The non-volatile 256 x 16 EEPROM is used to store system configuration information. The FPGA provides combinational and sequential logic for generating interface signals between such devices as the dual port RAM, Defibrillator option slot and FLASH memory. All of these devices are larger equivalents of ones used in the PageWriter 200i design.

## Dual Port Ram

The 4k x 8 dual-port RAM device is an off-the-shelf component provides two independent hardware ports accessing a common memory region, and controls arbitration of that common memory. The dual-port memory device provides a common memory area that can be accessed by either the 12-Lead sub-system or the defibrillator sub-system. The primary purpose is to provide the interface through which the 12-Lead report data can be sent to the defibrillator printer. Various other data and control information is also communicated via this device.

## System Gate Array

The 12-Lead system gate array is the same device used in the PageWriter 200i. It serves numerous functions including ECG F/E control, DMA for ECG and 12-Lead LCD display data, 12-Lead keyboard scan, and 12-Lead display control.

## Data Communication

The CPU communicates with two external data ports using the dual UART. This is the same device used in the Storage and Transmission Option (#A05) of the PageWriter 200i. It translates between serial and parallel data to implement two RS232 ports.

One of the ports connects directly with an (optional) internal V.34 modem module. This module consists of a self-contained data/fax/cellular modem and is an off-the-shelf component. The modem interfaces between the dual UART and a standard RJ-11 phone jack mounted on the case. Power for the modem module comes from the modem power supply that is controlled by the system gate array. This port allows connection to either land or cellular phone lines for transmission of ECG reports.

The other port interfaces through the RS232 level translators with a DB-9 serial interface connector mounted on the case. These are the same devices used in the Storage and Transmission Option (#A05) of the PageWriter 200i. This port allows connection of an external modem for transmission of ECG reports. It is also used to download program memory into the FLASH memory devices.

# Defibrillator-Pacer Patient Connections

The defibrillator provides support for the following methods of delivering defibrillation or pacing energies to the patient:

• Standard external paddles

• External adhesive pads

## Standard External Paddles

The Standard External Paddle Set combines Adult and Pediatric defibrillation electrode surfaces in one paddle design. The Sternum paddle has a Paddle Contact Indicator (PCI), and a Shock button. The Apex paddle has the CHARGE INITIATION button, a CHARGE DONE LED, and a Shock button.

The defibrillator determines paddle type by measuring the voltage on the CHDONE control line. The voltage range for a valid External Paddle Set is 0.5 - 3.0 V. The Shock switches pull their respective lines (nDischarge Sternum, nDischarge Apex) to logic ground when pressed. Single fault tolerance is maintained throughout the discharge control path for operator safety. The Charge switch pulls the nCharge line low when pressed.

## External Adhesive Pads

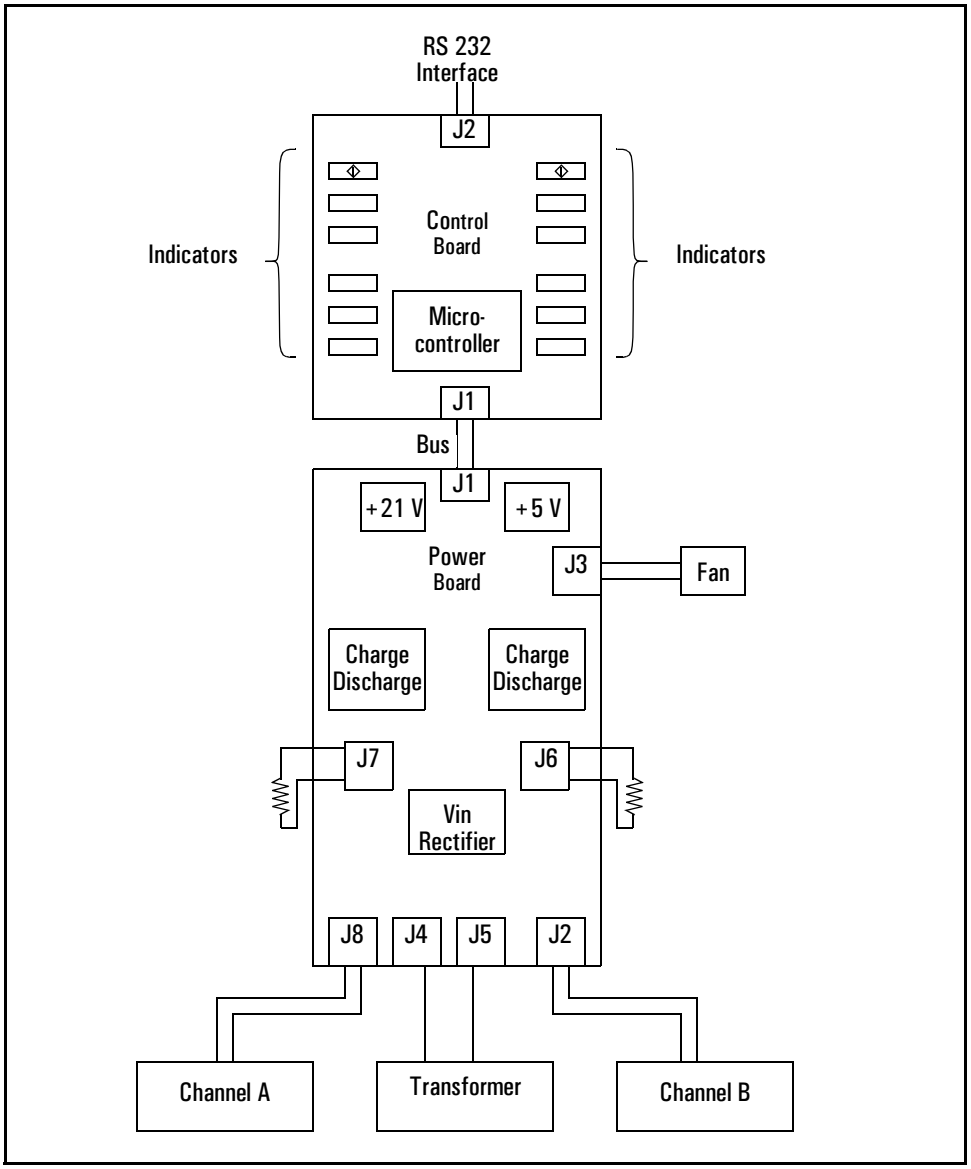
The External Adhesive Pads are connected to the defibrillator using an auxiliary connector on the pads adaptor cable. External Pacing and Defibrillation can be performed through this connection. The defibrillator is discharged by pressing two shock buttons located on the defibrillator connector housing.

The defibrillator determines paddle type by measuring the voltage on the CHDONE control line. The voltage range for a valid external adhesive Pads adaptor is 3.0 - 4.0 V.

# M2480B Battery Support System Theory

The M2480 battery support system provides battery charging and discharging for two (Channel A and Channel B) Nickel Cadmium (NiCd) batteries. The battery system can either source or sink current on both channels simultaneously and independently.

**Figure 6-12**




**Battery Support System Block Diagram**

The battery support system is divided into two major sub-assemblies as shown in Figure 6-11: the control board and power board. The control board contains the micro-controller and the user interface. The power board contains all of the power converters, including the battery charger/dischargers and the internal supplies.

## M2480B Control Board

The control board contains

• Micro-controller

• Light bars, LEDs and Switches

• Serial EEPROM

• Analog to Digital Converters

• Digital to Analog Converter

• RESET and POWERFAIL Generation

• Serial Port

• Address Decoder PAL

### Micro-controller

An Intel 87C196KD (196) micro-controller is used to control the battery support system. The 196 is configured to run from internal ROM and utilize an eight bit external data bus. The micro-controller is clocked by a 16.000 MHz clock oscillator.

### Light Bars, LEDs and Switches

The battery support system has six light bars, a test button LED, and a test button for each channel. In addition, the battery support system has a single AC power light bar. The light bars for each channel are used to indicate the operational status of the charger channel. The LED for each channel is used to request a capacity test for the corresponding charger channel. The button for each channel is used to initiate a capacity test for the corresponding charger channel. The AC power light is illuminated when valid AC mains voltage is present.

### Serial EEPROM

The battery charger control board uses a serial EEPROM for non-volatile memory. The serial EEPROM, which is used to store calibration constants, shares the micro-wire interface with the serial A/D converter.

### Analog to Digital Conversion

The control board has two A/D converters that are powered by a high precision reference. The first is located in the micro-controller and is used to measure current, ID resistors, thermistors, temperature sensor and low voltage power supplies. The second converter is used to measure the battery voltages.

### Digital to Analog Conversion

The micro-controller PWMs are used to provide the analog outputs. These signals are low-pass filtered to produce a control voltage for the associated battery charger/discharger.

### RESET and POWERFAIL

The POWERFAIL signal is a square wave of twice the power line frequency. The pulse train occurs when the rectified signal +sFVCROW is greater than 1.27 V. Upon removal of the POWERFAIL pulse train (+sFVCROW < 1.27 V), the system disables both channels. The system is held in reset while the +5V supply is less than 4.5V.

### Serial Port

The micro-controller serial lines are connected to a serial transceiver to form an RS-232 serial port.

### Address Decoder PAL

The control board uses a 16V8 PAL to decode external memory accesses. The lower byte of the address is latched by a 74HC573. Two 74HC273s are used to latch the light bar data. The control board has 32 Kbytes of SRAM. This RAM is mapped into the upper half of the processor address space.

## M2480B Power Board

The power board supplies and controls the required voltages for the M2480 battery support system. The main components of the power board are:

- Crowbar circuit
- Battery connection
- Fan drive circuit
- Internal voltage supplies
- Control PAL
- Battery charge and discharge circuits

### Crowbar Circuit

The crowbar circuit prevents battery support system damage during an AC overvoltage condition, which may be caused by an incorrect voltage selection setting. This circuit senses when Vin is too high and then crowbars Vsec to ground with an SCR so that the AC mains user-replaceable fuses blow.

Vcrow is rectified and used as an attenuated input to a control board voltage supervisor circuit that generates a 100/120 Hz AC mains interrupt for CPU detection of AC mains presence. Vcrow is also rectified and filtered to use as a high voltage source to turn on MOSFETs (in the battery charge/discharge circuit outputs) that isolate the battery from parasitic discharge when AC power is not present. The MOSFET drives are crowbarred off and the fault latches are set if a Vcrow undervoltage occurs.

Vsec over-voltage is sensed at Vin. This enables the crowbar sense and source of power to stay up until well after the crowbar function has occurred. The crowbar sense trip range is 45.74 to 49 V on Vin.

### Battery Connections

When a battery is inserted, contact is made to connect Vbat to the power board through a 3.3 Ω resistor. This allows some time to charge the power board capacitance without creating a current surge.

The Vbat sense circuit is configured as a differential amplifier (O to 20 V Vbat produces 0 to 5 V output). This output is connected to the control board analog to digital converter.

The power board is protected from the battery energy capacity under fault conditions by a 4 A fuse.

### Fan Drive Circuit

The internal DC fan is powered from the +21 V source and is enabled each time a battery is being charged or discharged, or if the internal charger temperature exceeds a specified limit. The control board CPU is in control of this function.

### Internal Voltage Supplies

Two switching supplies run off of Vin to provide a regulated +21 V and +5 V power source. The maximum output loads are 300 mA and 400 mA respectively. The +21 V power source ranges from 20.1 to 22 V. The +5 V power source ranges from 4.79 to 5.24 V.

### Control PAL

Some power board functions are implemented by a control PAL and a schmidt trigger NAND gate.

The NAND gates are wired as SR latches and used to latch the charger output overvoltage occurrence, battery over-temperature or Vcrow voltage sag. The comparator outputs are open collector with 1 KΩ pullups. The SR latch outputs are wired to the PAL and to the control board for CPU input.

The control PAL implements the charge, discharge and battery disconnection MOSFET controls. The control board supplies charge and discharge controls. The PAL qualifies their signals to prevent illegal modes and converts them to drive the PWM shutdown pins. It also shuts down the battery disconnect MOSFETs when no charge or discharge function is enabled or a fault is set.

### Battery Charge and Discharge Circuits

Both battery charge and discharge circuits are identical and share a common topology. Charge and discharge are controlled by independent PWMs of which only one is enabled at a time.

The charge PWM operates with the high side p-channel MOSFET switch as a buck regulator. The discharge PWM operates with the low side n-channel MOSFET as a boost regulator. This side boosts the battery voltage to charge up Vin. Both PWMs have separate feedback compensation but use common average current sensing provided by the high side current sense amplifier. The amplifier has current output which is converted to voltage by a resistor. This voltage is sent to the control board analog to digital converter and is buffered by voltage followers for the PWM feedback. This buffer prevents interaction of the PWM feedback compensation impedance.

Both PWMs use the same main inductor and have instantaneous current limiting provided by a 0.05 Ω resistor. This results in a 3 to 4 A peak current limit.

## M2480B Power Rectifier Circuit

The transformer secondary output (Vsec) is connected directly to the power board. On the power board, Vsec is full-wave rectified, filtered by two 12,000 µF capacitors and fused with a 7 A fuse.

## M2480B Software

### User Interface Software

The battery support system has two modes of operation. The default mode is CHARGE; the secondary mode is TEST. Following a capacity test the charger channel returns to CHARGE mode. Pressing (Test) changes the battery support system mode from CHARGE to TEST, and the TESTING light bar is asserted. If the capacity gauge of the battery does not respond, or if there have been too many charges since the last test, or if any of several status bits is set, the battery support system determines that a capacity test is recommended and the test LED blinks until (Test) is pressed or the battery is removed.

The user interface software includes a self test used to verify the integrity of the battery support system, provides serial port command status for each battery, provides a battery ID register used as a mailbox for questionable battery operation, and generates fault codes if the battery support system malfunctions.

### Self Test

The self test is executed at power up and from the debug monitor and functions whether or not the batteries are present (regardless of their condition). Tests include: ROM, RAM, and EEPROM, a light pattern, voltage sensing, charge/
discharge verification, and battery current (if a battery is present). If a fault is detected, the fault light for the affected channel(s) blinks. The light for that test will also be on. See Table 6-16 for a description of the faults.

### Serial Port Communications

The user may query the battery support system using the serial port to check the state of the battery and the battery support system. A tabular list of the commands accepted is provided in Chapter 5, *Troubleshooting*.

# M2476B/M2477B NiCd Batteries

M2476B/M2477B NiCd batteries provide the high-energy delivery rates required by the HP CodeMaster 100 Portable Defibrillator/Monitor. These small, lightweight batteries can be recharged to 100% capacity within two to three hours and have a significantly longer cycle life than comparable batteries (such as SLA).

## Transport Defibrillator Usage

Transport defibrillators generally operate on battery power for extended periods of time. When in use, the battery might cycle from a fully charged state to a deep or completely discharged state and then might not be recharged for an extended period of time. NiCd batteries are well suited for this environment where cyclic application is the norm.

## NiCd versus SLA Characteristics

NiCd batteries are smaller and weigh less than SLA batteries, but lose a charge faster (approximately 30% per month as opposed to only 5% capacity loss for SLA over the same period). NiCd batteries are more tolerant of deep discharges and undercharging, but are subject to voltage depression caused by repeated partial discharging and recharging. Refer to *Understanding the Differences between Nickel Cadmium and Sealed Lead Acid Batteries* (HP PN 5963-9445E) for more information.

## Maintaining NiCd Batteries

NiCd batteries require periodic reconditioning (capacity testing) to maintain peak condition. Recondition NiCd batteries every 90 days by performing a capacity test. The capacity test takes approximately 24 hours. Refer to the *HP CodeMaster 100 Portable Defibrillator/Monitor User's Guide* for detailed information on performing the battery capacity test.

## Battery Maintenance Guide

The HP M2476B and M2477B NiCd batteries are used to power the HP CodeMaster 100 Defibrillator/Monitor with Integrated 12-Lead ECG Option. Proper evaluation and care procedures ensures that these batteries have the energy required to operate the defibrillator and deliver the appropriate therapy. For information on the HP M2476B and HP M2477B battery support systems, battery evaluation aids, and evaluation and care procedures, refer to the *HP M2476B & M2477B Battery Evaluation and Care User's Guide* (M2475-92100).

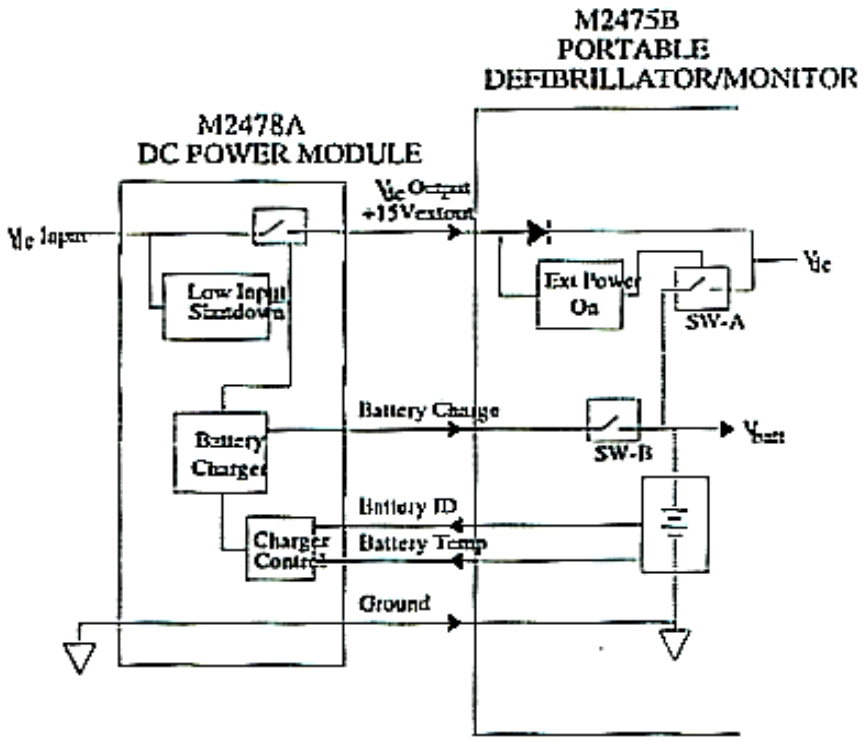
# M2478A DC Power Module Theory

The M2478A DC Power Module can be used to power the M2475B Portable Defibrillator/Monitor using a vehicle's DC power distribution system (12V lead acid battery). In addition, the M2478A will charge the M2476B and M2477B portable defibrillator/monitor battery packs.

## M2478A to M2475B Interconnection Diagram

A diagram of the M2478A to M2475B interconnections is shown in Figure 6-12.This figure also shows a block diagram of the M2475B power system, identifying the connection of the battery to either the charger or the defibrillator. When external power is supplied to the defibrillator, the defibrillator battery is connected to the DC power module (Switch B closed). The battery is disconnected from the defibrillator (Switch A open), and external power is used to power the defibrillator. With no external power supplied, the defibrillator is powered from the battery (Switch A closed), and battery voltage is not available to the Battery charger (Switch B open).

**Figure 6-13**




**M2478A DC Power Module to M2475B CodeMaster 100 Interconnection Diagram**

# Parts Lists

## Introduction

This chapter contains parts lists for these assemblies:

- Components above the PAC assemblies
- Components below the PAC assemblies
- Components outside the chassis
- Front bezel assemblies

See the *HP M2475B CodeMaster 100 Portable Defibrillator/Monitor User's Guide* for a list of supplies.

# Ordering Information

To order medical supplies, including batteries:

• In the U.S. only - call 1-800-225-0230

• Worldwide - visit our Medical Supplies website at:

www.hp.com/go/medsupplies

# Calling for Assistance

The AC and DC Power Modules may be returned to HP for service by contacting your local HP response center. For the phone number of your response center, please call the HP regional office nearest to you:

### United States of America:
Hewlett-Packard Company
Medical Products Group
Headquarters
3000 Minuteman Road
Andover, Massachusetts
1-800-934-7372

### Latin America:
Hewlett-Packard Latin America
5200 Blue Lagoon Drive
9th Floor
Miami, Florida 33126
(305) 267-4220

### Canada:
Hewlett-Packard (Canada) Lts.
5150 Spectrum Way
Mississauga, Ontario L4w 5GI
(905) 206-4725

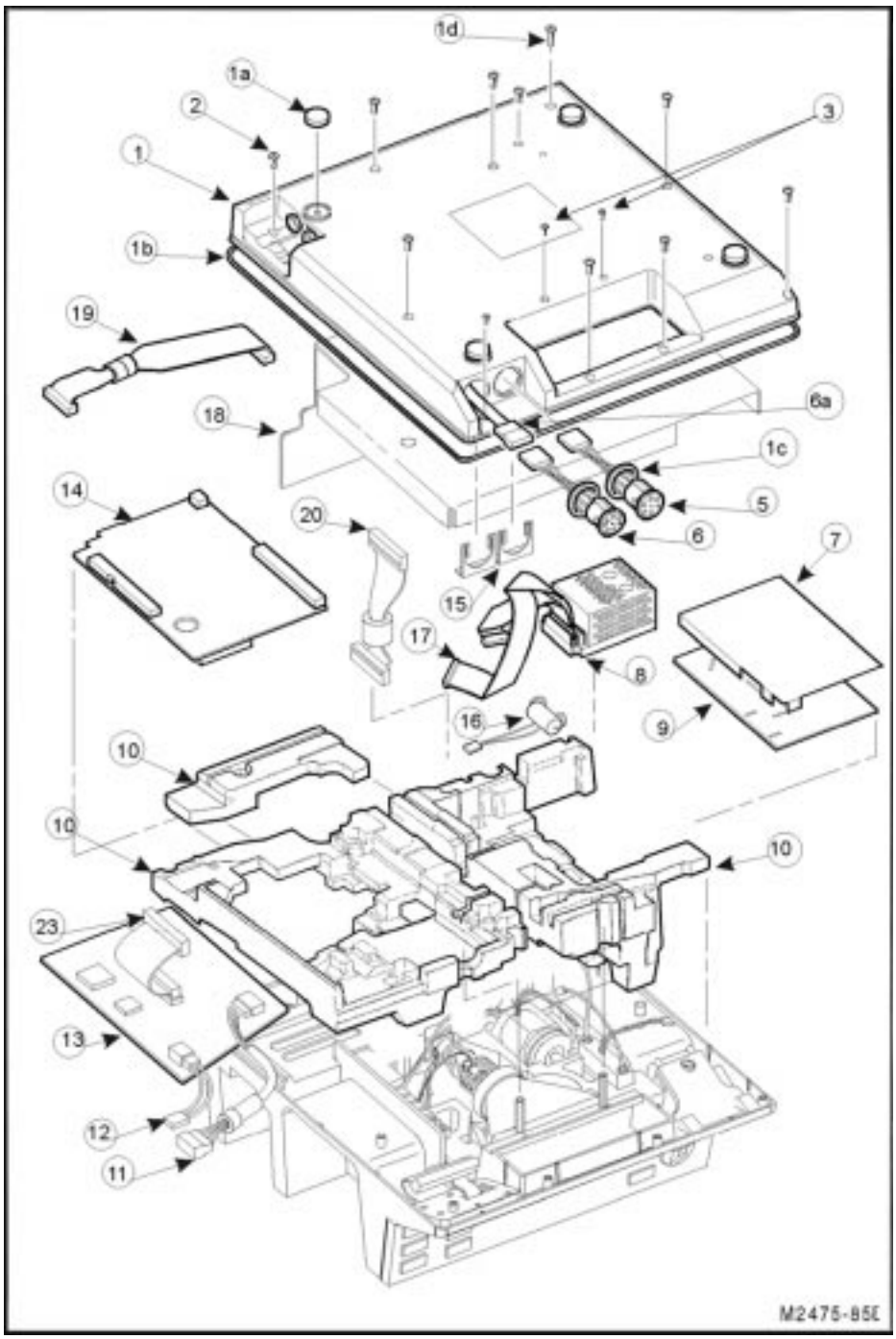
### Medical Distribution:
Europe/Middle East/Africa
39 rue Veyrot
1217 Meyrin 1
Geneva, Switzerland
(+41) 22 780 4111

### Marketing Center Europe:
Hewlett-Packard GmbH
Schickardstr.4
71034 Boeblingen
Germany
Fax: (+49) 7031 14 4096

### Asia Pacific Headquarters:
Hewlett-Packard Asia Pacific Ltd.
17-21/F Shell Tower, Times Square
1 Matheson Street, Causeway Bay
Hong Kong
(+852) 2599 7777

# Above PAC Assemblies

**Figure 7-1**




**Above PAC Assemblies**

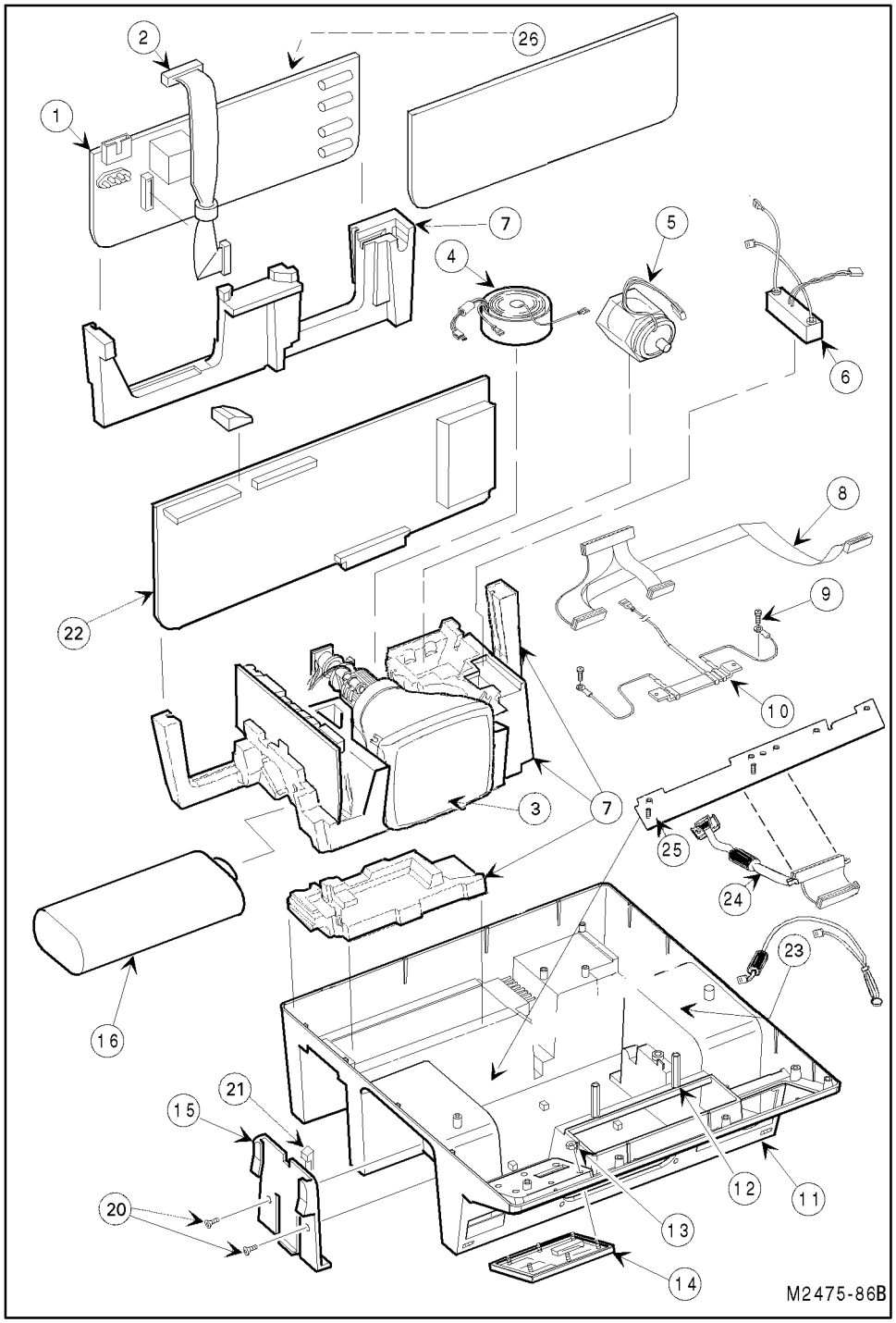
**Table 7-1** **Above PAC Parts List**

| Ref. No. | Description | Part No. |
|---|---|---|
| 1 | Bottom case assembly* | M2475-69550 |
| 1a | Foot-plastic (4) | 0403-0767 |
| 1b | Case gasket | M2475-07308 |
| 1c | ECG/$SpO_2$ gaskets (2) | M2475-07306 |
| 1d | Screw-M3x.5 12mm (1) | 0515-0374 |
| 2 | Screw-M3x.5 8mm (10) | 0515-0372 |
| 3 | Screw-M3x.5 6mm FH (2) | 0515-1946 |
| 5 | Cable assembly, - $SpO_2$ | M2475-62608 |
| 6 | ECG jumper cable | M2475-62627 |
| 6a | ECG 12-Lead interface cable | M2475-62628 |
| 7 | High voltage shield | M2475-07605 |
| 8 | DC power supply (12-Lead) C90 | M2475-60711 |
| 9 | High voltage charger board | M2475-60210 |
| 9a | Fuse 25 A 32 V (not shown) | 2110-0250 |
| 10 | PAC Kit (C90) | M2475-47430 |
| 11 | $SpO_2$ interface cable assembly | M2475-62621 |
| 12 | $SpO_2$ keyboard jumper cable | M2475-62622 |
| 13 | $SpO_2$ board | M1722-60102 |
| 14 | Control board with shock advisory (12-Lead) | M2475-60204 |
| 15 | Retainers - $SpO_2$ and ECG input connectors | M2475-07101 |
| 16 | Lithium backup battery | M2475-62604 |
| 17 | DC supply cable assembly | M2475-62619 |
| 18 | Image plane shield | M2475-07606 |
| 19 | High voltage/control board cable assembly | M2475-62610 |
| 20 | CRT cable | M1722-61619 |
| 21 | Shields (not shown): CRT deflector board, DC supply, DC supply cable | M2475-07608 |
| 22 | Beeper assembly (not shown) | M2475-62614 |
| 23 | $SpO_2$ BUS cable (12-Lead) (not shown) | M2475-62634 |
| 24 | Connector support assembly (not shown) | M2475-27405 |

* Includes bottom case, plastic feet, recorder drain gasket, case gasket, ECG/$SpO_2$ gaskets, ECG out connector assembly, external power connector assembly, and beeper seal.

# Below PAC Assemblies

**Figure 7-2**




**Below PAC Assemblies**

**Table 7-2** **Below PAC Assemblies Parts List**

| Ref. No. | Description | Part No. |
|---|---|---|
| 1 | ECG front end/pacer board | M2475-60221 |
| 2 | ECG control board cable assembly | M2475-62609 |
| 3 | CRT assembly | M2475-62830 |
| 4 | Patient inductor | M2475-83801 |
| 5 | Patient relay | M2475-83803 |
| 6 | Safety relay | M2475-626I6 |
| 7 | PAC Kit C90 | M2475-47430 |
| 8 | Keypanel cable assembly | M2475-62607 |
| 9 | Screw-M3.5 x 4 mm (2) | 0515-0663 |
| 10 | Test load assembly | M2475-62605 |
| 11* | Top case assembly - English | M2475-69660 |
| | Top case assembly - French | M2475-69661 |
| | Top case assembly - German | M2475-69662 |
| | Top case assembly - Dutch | M2475-69663 |
| | Top case assembly - Spanish | M2475-69664 |
| | Top case assembly - Italian | M2475-69665 |
| | Top case assembly - Swedish | M2475-69666 |
| | Top case assembly - Norwegian | M2475-69668 |
| | Top case assembly -Finnish | M2475-69669 |
| 12 | Standoff-M3x27 HEX (2) | 0380-3060 |
| 13 | Nut - Hex M3 x 0.5 W/LKW (6) | 0535-0031 |
| 14 | Pacer/$SpO_2$ keypanel assembly- English | M2475-69520 |
| | Pacer/$SpO_2$ keypanel assembly - French | M2475-69521 |
| | Pacer/$SpO_2$ keypanel assembly - German | M2475-69522 |
| | Pacer/$SpO_2$ keypanel assembly - Dutch | M2475-69523 |
| | Pacer/$SpO_2$ keypanel assembly - Spanish | M2475-69524 |
| | Pacer/$SpO_2$ keypanel assembly - Italian | M2475-69525 |
| | Pacer/$SpO_2$ keypanel assembly - Swedish | M2475-69526 |

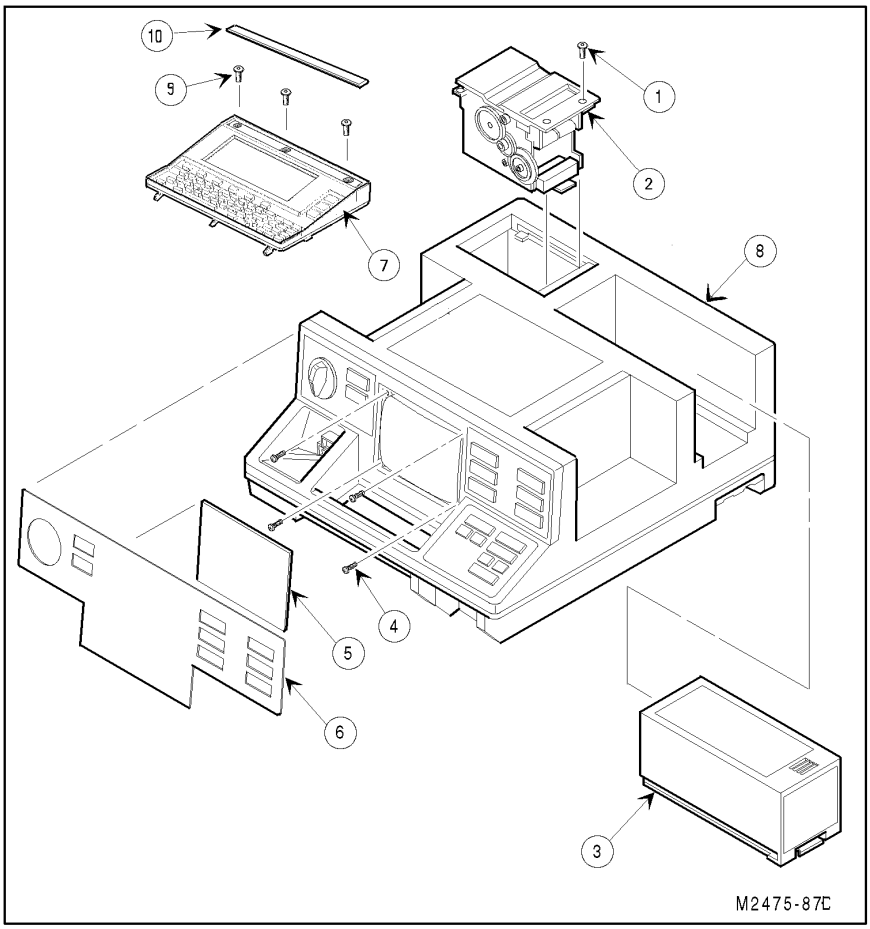
* Top case assemblies include: top case, all gaskets, CRT lens, battery cable assembly, recorder cable assembly, paddle connector assembly, language case label set and bezel overlay.

**Table 7-2** **Below PAC Assemblies Parts List (Continued)**

| Ref. No. | Description | Part No. |
|---|---|---|
| | Pacer/$SpO_2$ keypanel assembly - Norwegian | M2475-69528 |
| 15 | Paddle retainer (2) | M2475-47323 |
| 16 | Patient capacitor | M2475-83802 |
| 18 | ECG front end/pacer board shield (not shown) | M2475-07604 |
| 19 | Patient relay gasket (not shown) | M2475-07310 |
| 20 | Screw-M3.5 x 4 mm (4) | 0515-2044 |
| 21 | Clip | M2475-07103 |
| 22 | ECG System board; 12-Lead with modem, English<br>ECG System board; 12-Lead with modem, French<br>ECG System board; 12-Lead without modem, English<br>ECG System board; 12-Lead without modem, French<br>ECG System board; 12-Lead without modem, German<br>ECG System board; 12-Lead without modem, Dutch<br>ECG System board; 12-Lead without modem, Spanish<br>ECG System board; 12-Lead without modem, Italian | M2475-60270<br>M2475-60271<br>M2475-60260<br>M2475-60261<br>M2475-60262<br>M2475-60263<br>M2475-60264<br>M2475-60265 |
| 23 | Modem cable | M2475-62642 |
| 24 | RS232 interface | M2475-62635 |
| 25 | Insulator | M2475-07111 |
| 26 | Shield | M2475-07604 |

# Outside Chassis Assemblies

**Figure 7-3**




**Outside Chassis Assemblies**

**Table 7-3 Outside Chassis Assemblies Parts List**

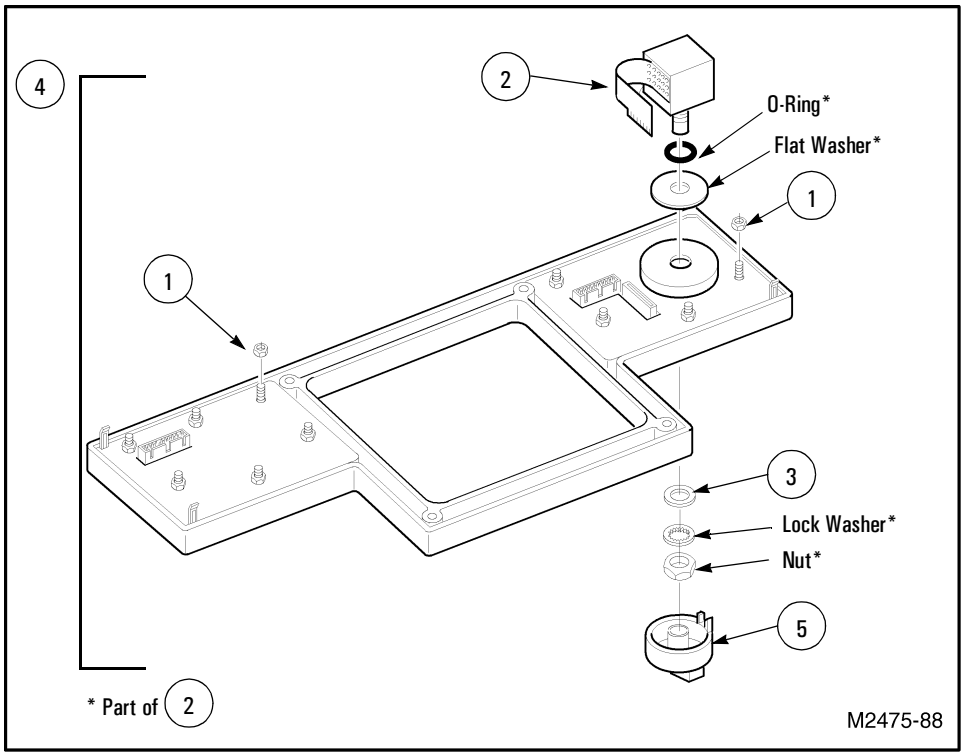
| Ref. No. | Description | Part No. | Part Number with Shock Advisory |
|---|---|---|---|
| 1 | Screw-3MM X 8 (4) | 0515-0372 | |
| 2 | Recorder | M1722-69520 | |
| 3 | 2.5 Ah battery<br>4.0 Ah battery | M2476B<br>M2477B | |
| 4 | Screw - M3 X.5 (4) | 0515-0372 | |
| 5 | CRT lens | M2475-47521 | |
| 6 | Bezel overlay - English | M2475-84500 | M2475-84510 |

**Table 7-3 Outside Chassis Assemblies Parts List (Continued)**

| Ref. No. | Description | Part No. | Part Number with Shock Advisory |
|---|---|---|---|
| | Bezel overlay - French | M2475-84501 | M2475-84511 |
| | Bezel overlay - German | M2475-84502 | M2475-84512 |
| | Bezel overlay - Dutch | M2475-84503 | M2475-84513 |
| | Bezel overlay - Spanish | M2475-84504 | M2475-84514 |
| | Bezel overlay - Italian | M2475-84505 | M2475-84515 |
| | Bezel overlay - Swedish | M2475-84506 | M2475-84516 |
| | Bezel overlay - Norwegian | M2475-84507 | M2475-84518 |
| | Bezel overlay - Finnish | M2475-84508 | M2475-84519 |
| 7 | Bezel Keypad Assembly - English with modem | M2475-69610 | |
| | Bezel Keypad Assembly - French without modem | M2475-69611 | |
| | Bezel Keypad Assembly - German without modem | M2475-69612 | |
| | Bezel Keypad Assembly - Dutch without modem | M2475-69613 | |
| | Bezel Keypad Assembly - Spanish without modem | M2475-69614 | |
| | Bezel Keypad Assembly - Italian without modem | M2475-69615 | |
| | Bezel Keypad Assembly - Swedish without modem | M2475-69616 | |
| | Bezel Keypad Assembly - Norwegian without modem | M2475-69618 | |
| | Bezel Keypad Assembly - Finnish without modem | M2475-69619 | |
| | Bezel Keypad Assembly - English without modem | M2475-69620 | |
| | Bezel Keypad Assembly - French with modem | M2475-69622 | |
| 8 | Top Case Assembly - English | M2475-69660 | |
| | Top Case Assembly - French | M2475-69661 | |
| | Top Case Assembly - German | M2475-69662 | |
| | Top Case Assembly - Dutch | M2475-69663 | |
| | Top Case Assembly - Spanish | M2475-69664 | |
| | Top Case Assembly - Italian | M2475-69665 | |
| | Top Case Assembly - Swedish | M2475-69666 | |
| | Top Case Assembly - Norwegian | M2475-69668 | |
| | Top Case Assembly - Finnish | M2475-69669 | |
| 9 | Screw (3) | 0515-0372(3) | |
| 10 | Bezel key pad label | M2475-84710 | |

# Front Bezel Assembly

**Figure 7-4**




**Front Bezel Assembly**

**Table 7-4 Front Bezel Assembly Parts List**

| Ref. No. | Description | Part No. | Part No. with Shock Advisory |
|---|---|---|---|
| 1 | Nut - hex M3X0.5 W/LKW (For reference only.) | 0535-0031 | |
| 2 | Switch assembly, energy select (For reference only.) | M1722-61900 | |
| 3 | Washer-5/16 FL metallic (For reference only.) | 2190-0833 | |
| 4* | keypanel assembly - English (shown in entirety in Figure 7-4) | M2475-69500 | M2475-69540 |
| | keypanel assembly- French | M2475-69501 | M2475-69541 |
| | keypanel assembly- German | M2475-69502 | M2475-69542 |
| | keypanel assembly- Dutch | M2475-69503 | M2475-69543 |
| | keypanel assembly- Spanish | M2475-69504 | M2475-69544 |
| | keypanel assembly- Italian | M2475-69505 | M2475-69545 |
| | keypanel assembly- Swedish | M2475-69506 | M2475-69546 |
| | keypanel assembly- Norwegian | M2475-69508 | M2475-69549 |
| 5 | Energy select knob (For reference only.) | M2475-69570 | |

* includes energy select switch

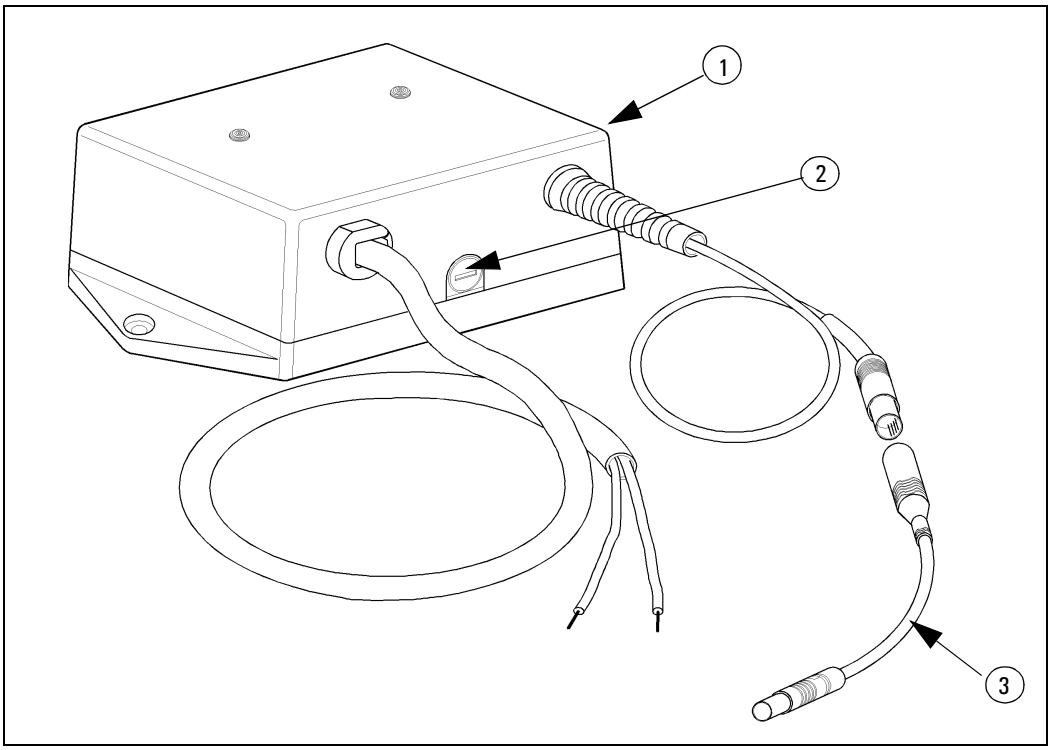
# M2480B Battery Support System

**Table 7-5** **M2480B Battery Support System**

| Description | Part Number | Comment |
|---|---|---|
| Control PCA | M2480-60100 | |
| Power Supply PCA | M2480-60110 | |
| Power Transformer | M2480-62700 | |
| Fan Cable Assembly | M2480-69500 | |
| Fuse | 2110-1124 | 3.15 |
| Restored M2480B | | |
| English | M2480-68000 | ABB |
| French | M2480-68001 | ABF |
| German | M2480-68002 | ABD |
| Dutch | M2480-68003 | ABH |
| Spanish | M2480-68004 | ABE |
| Italian | M2480-68005 | ABZ |
| Swedish | M2480-68006 | ABS |
| Norwegian | M2480-68008 | ABN |

# M2478A DC Power Module

**Figure 7-5**



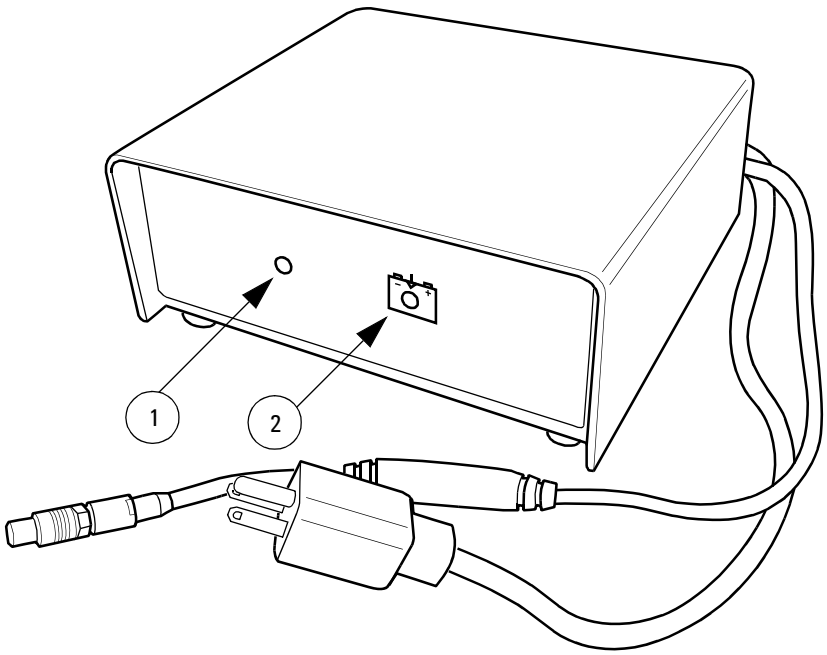

**M2478A DC Power Module**

**Table 7-6** **M2478A DC Power Module**

| Ref. No. | Description | Part No. |
|---|---|---|
| 1 | 12 VDC Power Module | M2475-69530 |
| 2 | Fuse, 10A, 250 V | 2110-0051 |
| 3 | Ext. Cable 12 VDC Power Module | M2475-69531 |

# M2479A AC Power Module

**Figure 7-6**




**External AC Power Module**

**Table 7-7** **M2479A AC Power Module**

| Ref. No. | Description |
|---|---|
| 1 | AC Power Indicator |
| 2 | Charging Indicator |

# Connector Pin Assignments

## General Information

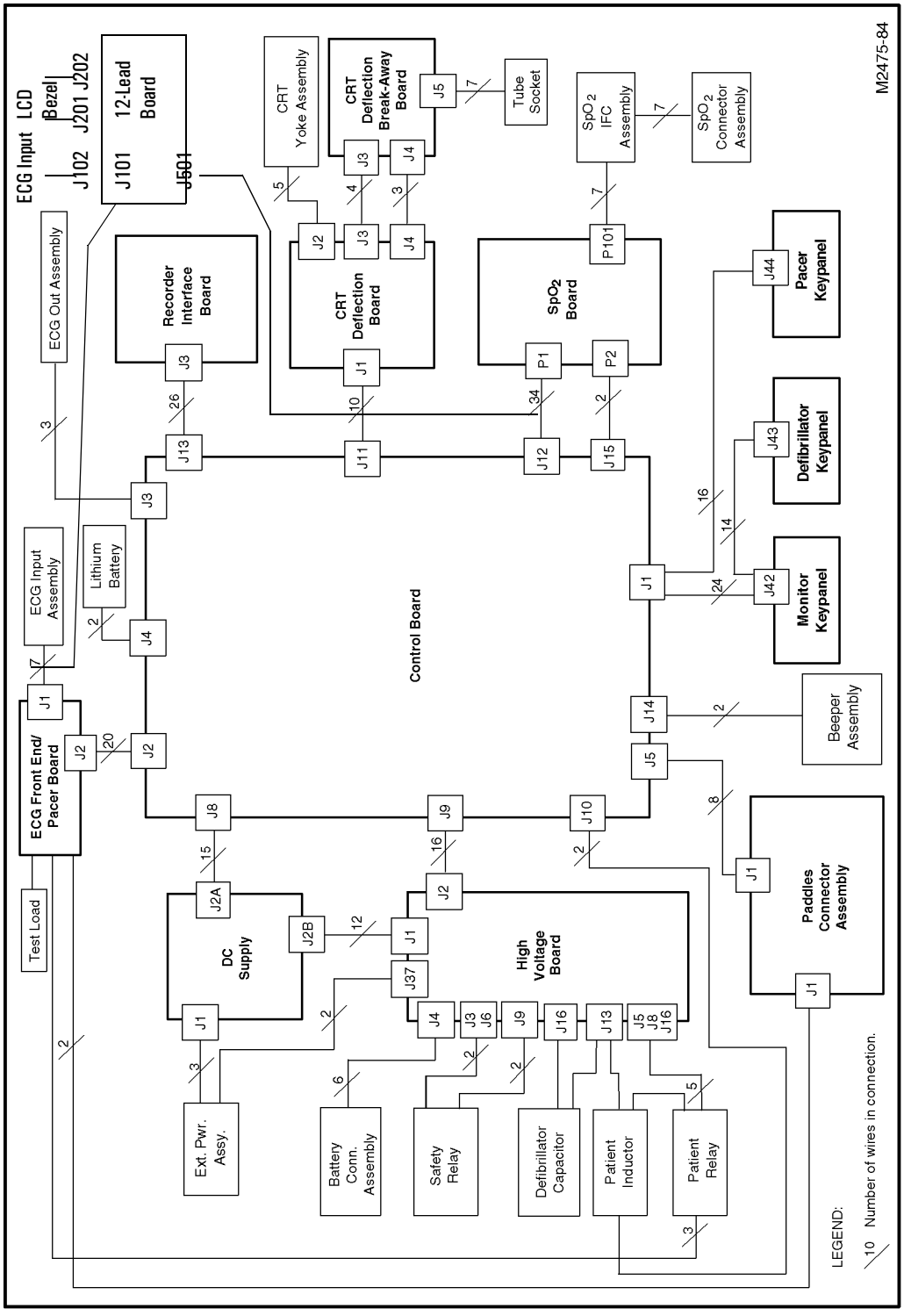
The tables in this appendix list the pin assignments for each connector on assemblies in the unit. Following each table is a dictionary of the signal names listed in the table. Some signal names begin with a letter that indicates the signal type:

| | |
|---|---|
| c | Connector signals. These have been conditioned for EMI purposes. |
| f | Filtered signals. These signals have been low-pass filtered to minimize the high frequency components that they would otherwise contain. |
| n | Active low signal. |
| p | Pulsed signals (except clock signals, which usually have “clk” embedded in their names.) |

Refer to Figure A-1 to see how the assemblies interconnect to the Control Panel. Pin assignments are given for these assemblies:

- Monitor keypanel
- Defibrillator keypanel
- Pacer keypanel
- ECG front end/pacer board
- ECG out assembly
- Lithium battery
- Paddles connector assembly
- DC supply
- High voltage charger board
- Patient inductor
- CRT deflection board
- $SpO_2$ board
- Recorder board
- Beeper assembly
- 12-Lead Board
- ECG Input Connector

**Figure A-1**




**Interconnect Block Diagram**

# Control Board Connectors

Refer to Figure A-1 for the control board connector locations. Connectors on the control board are listed in Table A-1.

**Table A-1 Control Board Connections**

| Control Board | Via Cable Assembly | Connects To | Reference |
|---|---|---|---|
| J1 | M2475-62607 | Monitor keypanel | Table A-2 |
| | | Defibrillator keypanel | Table A-3 |
| | | Pacer keypanel | Table A-4 |
| J2 | M2475-62609 | ECG front end/pacer board | Table A-5 |
| J3 | M2475-62618 | ECG out connector | Table A-6 |
| J4 | M2475-62604 | Lithium battery | Table A-7 |
| J5 | M2475-62617 | Paddles connector assembly | Table A-8 |
| J8 | M2475-62619 | DC supply | Table A-9 |
| J9 | M2475-62610 | High voltage charger board | Table A-10 |
| J10 | M2475-83801 | Patient inductor | Table A-11 |
| J11 | M1722-61619 | CRT deflection board | Table A-12 |
| J12 | M1722-60102 | $SpO_2$ board | Table A-13 |
| J13 | M2475-62606 | Recorder board | Table A-14 |
| J14 | M2475-62617 | Beeper assembly | Table A-15 |
| J15 | M2475-62622 | $SpO_2$ keys | Table A-16 |

**Table A-2** **Control Board J1 to Monitor Keypanel J42**

| Pin | Signal | Description |
|---|---|---|
| 1 | GROUND | |
| 2 | cnHISTKEY | A signal generated by the Review ● key—active low. Right side of ● Review ● key. |
| 3 | cHWID | |
| 4 | cnECGDEC | A signal generated by the ▼ ECG Size key—active low. Left side of key. |
| 5 | cnECGINC | A signal generated by the ECG Size ▲ key—active low. Right side of key. |
| 6 | cnALARMKEY | A signal generated by the HR Alarm key—active low. Controls HR Alarm functions. |
| 7 | cnREVIEWKEY | A signal generated by the ● Review key—active low. Left side of key. |
| 8 | cnLEADSKEY | A signal generated by the Lead Select key—active low. Selects the active lead. |
| 9 | cnMARKKEY | A signal generated by the Mark key—active low. Prints a mark. |
| 10 | cnPRINTSTOP | A signal generated by the Record key—active low. Starts and stops the recorder. |
| 11 | GROUND | |
| 12 | ESDGND | ESD ground. |
| 13 | GROUND | |
| 14-24 | No connection | |

**Table A-3** **Control Board J1 to Defibrillator Keypanel J43**

| Pin | Signal | Description |
|---|---|---|
| 11 | GROUND | |
| 12 | ESDGND | ESD ground. |
| 13 | GROUND | |
| 14 | cCHDLED | Charge Done LED. Lights the Charge Done LED in the apex paddle. |
| 15 | cSYNCLED | This signal lights the Sync LED when the unit is in sync mode. Asserted high. |
| 16 | cnPTAKEY | Reserved. |
| 17 | cnSYNCDEFIB | A signal generated by the Sync key on the keypanel—active low. Toggles between sync and defib operation modes. |
| 18 | cnCHARGEKEY | A signal generated by the (Charge) key on the keypanel—active low. Initiates a charge operation. |
| 19 | GROUND | |
| 20 | cnON | This signal turns the unit on—asserted low. |
| 21-24 | cENSEL [0], [1], [2], [3] | Energy Select. Four key bits set by the Energy Select control, which selects the charge level. |

**NOTE**

Note that pins 24 through 11 at J1 correspond to pins 1 through 14 at J43.

**Table A-4** **Control Board J1 to Pacer Keypanel J44**

| Pin | Signal | Description |
|---|---|---|
| 25 | GROUND | |
| 26 | cnPONOFF | Pacer On/Off. |
| 27 | cPACONLED | Pacer On LED. Drives the Pacer On LED on the pacer keypanel. The LED is on when the pacer function is turned on. |
| 28 | cnPSTSTOP | Pacer Start Stop. |
| 29 | cnPACPRES | Pacer Present. |
| 30 | cnPRATEINC | Pacer Rate Increase. |
| 31 | cnPRATEDEC | Pacer Rate Decrease. |
| 32 | cnPCURINC | Pacer Current Increase. |
| 33 | cnPCURDEC | Pacer Current Decrease. |
| 34 | cnPMODE | Pacer Mode. |
| 35 | cACONLED | External Power LED. |
| 36 | cBCHGLED | Battery Charge LED. |
| 37 | cVOLINC | Beeper Volume Increase. |
| 38 | cVOLDEC | Beeper Volume Decrease. |
| 39 | cnSPO2ONOFF | $SpO_2$ On/Off Key. |
| 40 | cnSPO2ALARM | $SpO_2$ Alarm Key. |

**NOTE** Note that pins 25 through 40 at J1 correspond to pins 1 through 16 at J44.

**Table A-5** **Control Board J2 to ECG Front End/Pacer Board J2**

| Pin | Signal | Description |
|---|---|---|
| 1 | cPACEN | Pacer Enable. Enables power to the pacer. |
| 2 | cPACCUR | Pacer Current. Sets pacer output current. |
| 3 | cPACMES | Pacer Measurement. Output current measured by the pacer and returned to the defibrillator controller. |
| 4 | GROUND | |
| 5 | cPACSYNCLK | Pacer Synchronous Clock. Synchronizes the pacer switching power supply to an even multiple of the ECG sample rate (96 kHz). |
| 6 | cHCVDC | High Current VDC (VDC+). Supplies primary power to the pacer. |

**Table A-5** **Control Board J2 to ECG Front End/Pacer Board J2 (Continued)**

| Pin | Signal | Description |
|---|---|---|
| 7 | cHCRET | High Current Return (VDC–). Return for HCVDC. |
| 8 | ESDGND | ESD ground. |
| 9 | GROUND | |
| 10 | cnFESENP | ECG Front End Serial Enable Paddles. |
| 11 | cFESENL | ECG Front End Serial Enable Leads. |
| 12 | cFESI | Front End Serial Data Input. |
| 13 | cFESO | Front End Serial Data Output. |
| 14 | cFEPEN | Front End Paddles Enable. |
| 15 | cFELEN | Front End Leads Enable. |
| 16 | cFESCLKI | Front End Serial Clock Input. |
| 17 | GROUND | |
| 18 | cFECHPCLK | Front End Chip Clock. Clock supplied to the ECG ASIC (2.048 MHz). |
| 19 | cFE5V | 5V to ECG front end/pacer board. |
| 20 | cFEPWRCLK | Front End Power Clock. The switching frequency of the front end power supplies (32 kHz). |

**NOTE**

Each pin on the control board J2 connects to a pin with the same number on the ECG front end/pacer board PCA J2.

**Table A-6** **Control Board J3 to ECG Out Connector**

| Pin | Signal | Definition |
|---|---|---|
| 1 | ESDGND (connects to sleeve) | Connects to the shield of the ECG Out cable, and ground on the control board. |
| 2 | cECGOUT (connects to tip) | ECG Out signal; 1V/1mV of the monitored source. |
| 3 | cINSTATE (connects to ring) | Instrument State. Indicates leads status: 0V = Off; 1.5V = On and Leads Off; 5V = On and Leads On. |

**Table A-7** **Control Board J4 to Lithium Battery**

| Pin | Signal | Definition |
|---|---|---|
| 1 | LITHRAW (LBAT+) | Lithium backup battery positive terminal. |
| 2 | GROUND (LBAT-) | Lithium backup battery negative terminal. |

**Table A-8** **Control Board J5 to Paddles Connector J1**

| Pin | Signal | Definition |
|---|---|---|
| 1 | cnPADCHG | Paddles Charge. Signal generated by the paddles charge button—active low. Initiates a charge operation. |
| 2 | cnDISCHGA | Discharge Apex. A signal asserted when the apex paddle shock button is pressed. |
| 3 | cCHDONELED | This signal is used for paddle type identification and it also lights the Charge Done LED in the apex paddle. |
| 4 | GROUND | |
| 5 | cPAD5V | 5V supply for the paddles. |
| 6 | GROUND | |
| 7 | cPCIDRV | This signal drives the PCI LED bar graph on the sternum paddle |
| 8 | cnDISCHGS | Discharge Sternum. A signal asserted when the sternum paddle shock button is pressed. |

**NOTE**

Each pin on the control board J5 connects to a pin with the same number on the paddles connector J1.

**Table A-9** **Control Board J8 to DC Supply J2A**

| Pin | Signal | Definition |
|---|---|---|
| 1 | cHCRET | High current return lines for HCVDC. |
| 2 | cPRN12V | Recorder 12 volt supply. Powers the stepper motor. |
| 3 | GROUND | |
| 4 | c12V | |
| 5 | c5V | |
| 6 | GROUND | |
| 7 | cPSSYNCLK | Power supply synchronizing clock (96 kHz). |
| 8 | cACON | Indicates that the supply is plugged into external power. |
| 9 | cPSON | Active low. Enables the DC/DC converter (+5V and +12V). |
| 10 | cVDC2 | A more filtered version of VDC for use in powering up start-up logic and static RAM. ORed with VBATT to form VBACKUP. |
| 11 | cSWADRIVE | Controls Switch A; when asserted (high), switch A is closed. |
| 12 | cHCVDC | High current VDC supply for recorder and pacer. |
| 13 | cHCRET | High current return lines for HCVDC. |
| 14 | cHCVDC | High current VDC supply for recorder and pacer. |
| 15 | cHCRET | High current return lines for HCVDC. |

**NOTE**

Each pin on the control board J8 connects to a pin with the same number on the DC supply board J2A.

**Table A-10** **Control Board J9 to High Voltage Charger Board J2**

| Pin | Signal | Definition |
|---|---|---|
| 1 | cHVDISCH | High Voltage Discharge. Logical NOR of nDISCHA and nDISCHS. |
| 2 | cDEFBSTAT | Defibrillator Status. A signal generated by the high voltage charger board to provide patient relay status. |
| 3 | cSSRY | Reserved. |
| 4 | cnCHGEN | Charge Enable. A signal asserted by the system gate array to initiate a charge cycle. Used in conjunction with CHRATE. |
| 5 | GROUND | |
| 6 | GROUND | |
| 7 | cOPNSFRLY | Open Safety Relay. A signal asserted by the system gate array which removes the 47 kΩ safety resistor which is normally across the defibrillator capacitor. |
| 8 | cQUALACON | AC On logic signal which is active only when +5V is present. |
| 9 | cVCAP | Voltage Capacitor. The capacitor voltage that is sampled to monitor the energy present across the defibrillator capacitor. |
| 10 | GROUND | |
| 11 | cVBATT | Battery voltage. |
| 12 | cPRDRV | Asserted by the system gate array to close patient relay, connecting the patient to the defibrillator capacitor. Qualified with HVDISCH on the high voltage charger board. |
| 13 | nBCHRGON | Reserved. |
| 14 | cCHRATE | Charge Rate. An analog signal used to set the charge rate. Used with CHGEN to initiate a charge cycle. |
| 15 | cBATSER | Serial communication between the defibrillator controller and the battery pack. |
| 16 | cBATID | Battery type identification. Identifies whether the battery is NiCad or SLA; including its capacity. |

**NOTE**

Each pin on the control board J9 connects to a pin with the same number on the high voltage charger board J2.

**Table A-11** **Control Board J10 to Patient Inductor**

| Pin | Signal | Definition |
|---|---|---|
| 1 | cIPEAK5V | 5 volt supply to the IPeak transformer. |
| 2 | cIPEAK | IPeak measurement signal from the IPeak transformer. |

**Table A-12** **Control Board J11 to CRT Deflection Board J1**

| Pin | Signal | Definition |
|---|---|---|
| 1 | GROUND | |
| 2 | cVSYNC | Vertical Sync signal. |
| 3 | GROUND | |
| 4 | cFBVID | Full Bright Video signal. |
| 5 | GROUND | |
| 6 | cHBVID | Half Bright Video signal. |
| 7 | GROUND | |
| 8 | cHSYNC | Horizontal Sync signal. |
| 9 | cCRT12V | 12 volt supply for the CRT. |
| 10 | cCRT12V | 12 volt supply for the CRT. |

**NOTE**

Each pin on the control board J11 connects to a pin with the same number on the CRT deflection board J1.

**Table A-13** **Control Board J12 to $SpO_2$ Board P1 and 12-Lead Board (J5XX)**

| Pin (SpO2) | Pin (12-Lead) | Signal | Definition |
|---|---|---|---|
| 1 | J501 | GROUND | |
| 2 | J502 | OAD(0) | Monitor address data bus bit 0. |
| 3 | J503 | OAD(1) | Monitor address data bus bit 1. |
| 4 | J504 | GROUND | |
| 5 | J505 | OAD(2) | Monitor address data bus bit 2. |
| 6 | J506 | OAD(3) | Monitor address data bus bit 3. |
| 7 | J507 | GROUND | |
| 8 | J508 | OAD(4) | Monitor address data bus bit 4. |
| 9 | J509 | OAD(5) | Monitor address data bus bit 5. |
| 10 | J510 | GROUND | |
| 11 | J511 | OAD(6) | Monitor address data bus bit 6. |
| 12 | J512 | OAD(7) | Monitor address data bus bit 7. |
| 13 | J513 | GROUND | |
| 14 | J514 | OMALE | Monitor Address Latch Enable. |
| 15 | J515 | GROUND | |
| 16 | J516 | nMRD | Monitor Read Strobe. |
| 17 | HCRET | GROUND | |
| 18 | J518 | nMWR | Monitor Write Strobe. |
| 19 | J519 | GROUND | |
| 20 | J520 | GROUND | |
| 21 | J521 | GROUND | |
| 22 | J522 | nOPTRDY | Option Ready Signal. |
| 23 | J523 | GROUND | |
| 24 | J524 | nOPTINT0 | Interrupt signals from options 0. |
| 25 | J525 | nOPTINT1 | Interrupt signals from options 1. |
| 26 | J526 | nOPTINT2 | Interrupt signals from options 2. |
| 27 | J527 | +DIGBACKUP | Digital Backup. A 5.0V low current regulated supply for powering battery backed-up logic on the $SpO_2$ option board. |
| 28 | J528 | nOPTSEL0 | Option Select. |

**Table A-13** **Control Board J12 to $SpO_2$ Board P1 and 12-Lead Board (J5XX) (Continued)**

| Pin (SpO2) | Pin (12-Lead) | Signal | Definition |
|---|---|---|---|
| 29 | 0+5V | +5V | |
| 30 | J530 | nOPTSEL1 | Option Select. |
| 31 | VDC | +12V | |
| 32 | J532 | nOPTSEL2 | Option Select. |
| 33 | J533 | nERAWRST | Raw Reset. A reset signal from the control board to the option slot. |
| 34 | J534 | nPRST | Reset. A monitor processor-controlled reset signal. |

**NOTE**

Each pin on the control board J12 connects to a pin with the same number on the $SpO_2$ board P1.

**Table A-14** **Control Board J13 to Recorder Board J3**

| Pin | Signal | Definition |
|---|---|---|
| 1 | cPRN12V | Printer +12 volts. Used to power the stepper motor. |
| 2 | cHCRET | High Current Return. |
| 3 | cPRN12V | Printer +12 volts. Used to power the stepper motor |
| 4 | cHCRET | High Current Return. |
| 5 | cMTRPH0 | Stepper motor phase 0. |
| 6 | cMTRPH1 | Stepper motor phase 1. |
| 7 | cMTRPH2 | Stepper motor phase 2. |
| 8 | cMTRPH3 | Stepper motor phase 3. |
| 9 | cPRN5V | Supplies logic power to the recorder. |
| 10 | GROUND | |
| 11 | cPCLK | Printer clock. Clocks data to the printhead. |
| 12 | cPDATA | Printer data. |
| 13 | cnPHSTB | Printhead Strobe. Enables the printhead dot printing. Duration of the strobe is controlled to compensate for printhead temperature and voltage. |
| 14 | cnPHLAT | Printhead latch. Latches a data column into the printhead. |
| 15 | cPAPOUT | Paper Out. Conditioned signal that indicates the paper out condition. |

**Table A-14** **Control Board J13 to Recorder Board J3 (Continued)**

| Pin | Signal | Definition |
|---|---|---|
| 16 | cTSENSE | Temperature Sense. An analog signal generated by a temperature sensor on the recorder; varies the duty cycle for the printhead write. |
| 17 | cSWPRNVDC | Switched printer VDC. A switched version of the VDC supply. |
| 18 | cHCRET | High Current Return. |
| 19 | cSWPRNVDC | Switched printer VDC. A switched version of the VDC supply |
| 20 | cHCRET | High Current Return. |
| 21 | cSWPRNVDC | Switched printer VDC. A switched version of the VDC supply |
| 22 | cHCRET | High Current Return. |
| 23 | SWPRNVDC | Switched printer VDC. A switched version of the VDC supply. |
| 24 | cHCRET | High Current Return. |
| 25 | cCAL | A voltage that encodes the printhead resistance; used to set the duty cycle for printhead writes. |
| 26 | ESDGND | Connects to the shield of the ECG Out cable. |

**NOTE**

Each pin on the control board J13 connects to a pin with the same number on the recorder board J3.

**Table A-15** **Control Board J14 to Beeper Assembly**

| Pin | Signal | Definition |
|---|---|---|
| 1 | PAOUT | Beeper output. |
| 2 | Ground | |
| 3 | PAOUT | |
| 4 | GROUND | |

**Table A-16** **Control Board J15 to $SpO_2$ Board P2**

| Control Board | | $SpO_2$ Board | | |
|---|---|---|---|---|
| **Pin** | **Signal** | **Pin** | **Signal** | **Definition** |
| 1 | SPONOFFKY | 1 | nONOFFKEY | |
| 2 | SPALARMKY | 2 | nALRMKEY | |

# ECG Front End/Pacer Board

These tables list the pin assignments for the connectors on the ECG front end/pacer board. The connectors and the assemblies they connect to are listed in Table A-17; other tables list connector pin assignments.

**Table A-17 ECG Front End/Pacer Board Connections**

| ECG Front End/Pacer Connector | Via Cable Assembly | Connects To | Reference |
|---|---|---|---|
| J1 | M2475-62627 | 12-Lead Board | Table A-18 |
| | | | Table A-19 |
| | | | Table A-20 |
| J2 | M2475-60609 | Control board | Table A-5 |
| J51, J61, J62 | M2475-83803 | Patient relay | Table A-21 |
| J63 | M2475-62605 | Test load | Table A-21 |
| J61 | M2575-62617 | Paddles connector | Table A-21 |
| J72 | M2575-62617 | Paddles connector | Table A-21 |

**Table A-18 ECG Front End/Pacer Board J1 to 12-Lead Board (J101)**

| ECG Front End/ Pacer Board | | ECG Input Connector | | |
|---|---|---|---|---|
| **Pin** | **Signal** | **Pin** | **Signal** | **Definition** |
| 1 | LREF | 1 | Shield | |
| 2 | RL | 7 | RL (5 wire) | Right Leg. |
| 3 | V | 3 | V1 | Chest. Lead |
| 4 | LA | 5 | LA | Left Arm. |
| 5 | LL | 4 | LL | Left Leg. |
| 6 | RA | 6 | RA | Right Arm. |
| 7 | LREF | 8 | Shield | |

# 12-Lead Board

The following tables list pin assignments on the 12-Lead board.

**Table A-19 12-Lead Board Connectors**

| 12-Lead Board Connector | Via Cable Assembly | Connects To |
|---|---|---|
| J101 | M2475-626279 | ECG Front End/Pacer Board |
| J102 | M2475-62628 | ECG Input Connector |
| J201 | M2475-62635 | LCD Bezel Assembly |
| P401 | M2575-62642 | LCD Bezel Assembly |
| J501 | M2575-62634 | Control/SpO2 Boards |

**Table A-20 12-Lead Board J102 to ECG Input Connector**

| Pin | Signal | Definition |
|---|---|---|
| 1 | V6 | Chest #6 |
| 2 | V5 | Chest #5 |
| 3 | V4 | Chest #4 |
| 4 | V3 | Chest #3 |
| 5 | V2 | Chest #2 |
| 6 | NIC | |
| 7 | RL | Right Leg |
| 8 | ID | cable ID |
| 9 | V1 | Chest #1 |
| 10 | LL | Left Leg |
| 11 | LA | Left Arm |
| 12 | RA | Right Arm |
| 13 | Shield | |

**Table A-21 12-Lead Board P401to RJ11 LCD Bezel Assembly**

| Pin | Signal | Definition |
|---|---|---|
| 7 | TIP | Pstn TIP Signal |
| 2 | Ring | Pstn Ring Signal |

**Table A-22 12-Lead Board J201 to LCD Bezel Assembly**

| Pin | Signal | Definition |
|---|---|---|
| 1 | DCOM | Ground |
| 3 | YD | Display data |
| 5 | VCCV | LCD Contrast Control |
| 7 | DCOM | Ground |
| 9 | LLOAD | Data Latch Signal |
| 11 | F+5KBD | +5V Supply |
| 13 | DCOM | Ground |
| 15 | DO3 | Display data |
| 17 | DO2 | Display data |
| 19 | DCOM | Ground |
| 21 | DO1 | Display data |
| 23 | DO0 | Display data |
| 25 | DCOM | Ground |
| 27 | nDOFF | Display Control Signal |
| 29 | COM | Ground |
| 31 | CP | Clock |
| 33 | DCOM | Ground |
| 35 | DCOM | Ground |
| 37 | DF | LCD Alternate Signal |
| 39 | DCOM | Ground |
| 2 | DCOM | Ground |
| 4 | ROWSD-1 | |
| 6 | ROWSD-0 | |
| 8 | ROWSC-1 | Keyboard Row Common |
| 10 | ROWSC-0 | |

| Pin | Signal | Definition |
|---|---|---|
| 12 | ROWSB-1 | |
| 14 | ROWSB-0 | |
| 16 | ROWSA-0 | |
| 18 | KEYCOL7 | |
| 20 | KEYCOL1 | |
| 22 | KEYCOL2 | Keyboard Column Common |
| 24 | KEYCOL3 | |
| 26 | KEYCOL4 | |
| 28 | KEYCOL5 | |
| 30 | KEYCOL6 | |
| 34 | SHIFT | |
| 36 | ALT | |
| 38 | NC | |
| 40 | DCOM | Ground |

**Table A-23 12-Lead Board J101 to ECG Front End/Pacer Board**

| Pin | Signal | Definition |
|---|---|---|
| 1 | SHIELD | |
| 2 | NC | |
| 3 | V1 | Chest |
| 4 | LL | Left Leg |
| 5 | LA | Left Arm |
| 6 | RA | Right Arm |
| 7 | RL | Right Leg |
| 8 | SHIELD | |

# ECG Input Connector

The ECG Input Connector (M2475-47350) connects to M2475-62628.

**Table A-24 ECG Input Connector to M2475-62628**

| Pin | Signal | Definition |
|---|---|---|
| 1 | RA | Right Arm |
| 2 | RL | Right Leg |
| 3 | ID | Cable ID |
| 4 | V3 | Chest #3 |
| 5 | V1 | Chest #1 |
| 6 | LL | Left Leg |
| 7 | LA | Left Arm |
| 8 | V2 | Chest #2 |
| A | V6 | Chest #6 |
| B | V5 | Chest #5 |
| C | SH | Shield |
| D | V4 | Chest #4 |

## ECG Out Connector

The ECG Out connector connects to J3 on the control board. See Table A-6 for pin assignments.

## Paddles Connector Assembly

The paddles connector assembly connects to J5 on the control board and to the ECG Front End/Pacer Board. Connections to the control board are shown in Table A-8 and connections to the ECG Front End/Pacer Board are shown in Table A-22.

**Table A-25** **Paddles Connector J1 and ECG Front End/Pacer Board J72 and J61-2**

| Paddles Connector Assembly | | ECG Front End /Pacer Board | | |
|---|---|---|---|---|
| **Pin** | **Signal** | **Pin** | **Signal** | **Definition** |
| A | HV-APEX | J72 | VAPEX | Connects the apex paddle (pad) to the output (-) side of the patient (transfer) relay and to pacer (-) terminal. |
| S | HV-STERNUM | J61-2 | VSTERNUM | Connects the sternum paddle (pad) to the output (+) side of the patient (transfer) relay and to the pacer (+) terminal. |

## Beeper Assembly

The beeper assembly connects to J14 on the control board. See Table A-14 for pin assignments.

## Defibrillator Keypanel

The defibrillator keypanel connects to J1 on the control board. See Table A-3 for pin assignments.

## Pacer Keypanel

The pacer keypanel J44 connects to control board J1. See Table A-4 for pin assignments.

## Monitor Keypanel

The monitor keypanel J42 connects to control board J1. See Table A-2 for pin assignments.

## DC Supply

These tables list the pin assignments for the connectors on the DC supply. The connectors and the assemblies they connect to are listed in Table A-23. Tables A-24 and A-25 list connector pin assignments for J2B and J1, respectively.

**Table A-26 DC Supply Connections**

| DC Supply Connector | Via Cable Assembly | Connects To | Reference |
|---|---|---|---|
| J2A | M2475-62619 | Control board | Table A-9 |
| J2B | M2475-62619 | High voltage charger board, J1 | Table A-24 |
| J1 | M2475-62620 | External power assembly | Table A-25 |

**Table A-27 DC Supply J2B to High Voltage Charger Board J1**

| DC Supply J2B | | High Voltage Charger Board J1 | | |
|---|---|---|---|---|
| **Pin** | **Signal** | **Pin** | **Signal** | **Definition** |
| 4 | GND | 12 | ESDGND | |
| 5 | CHGEXTOUT | 11 | CHGEXTOUT | |
| 6 | +12R | 10 | +12R | 12 volt supply. |
| 7 | GND | 9 | AGROUND | |
| 8 | VBATT | 8 | VBATT | Battery voltage. |
| 9 | VBATT | 7 | VBATT | |

**Table A-27** **DC Supply J2B to High Voltage Charger Board J1 (Continued)**

| DC Supply J2B | | High Voltage Charger Board J1 | | |
|---|---|---|---|---|
| **Pin** | **Signal** | **Pin** | **Signal** | **Definition** |
| 10 | GND | 6 | AGROUND | |
| 11 | VBATT | 5 | VBATT | |
| 12 | VDCOUT | 4 | VDCOUT | AC/DC converter voltage. |
| 13 | GND | 3 | AGROUND | |
| 14 | VDCOUT | 2 | VDCOUT | |
| 15 | VDCOUT | 1 | VDCOUT | |

**NOTE** J2B pins 1 through 3 are not used.

**Table A-28** **DC Supply J1 to External Power Connections**

| DC Supply Board J1 | | External Power | | |
|---|---|---|---|---|
| **Pin** | **Signal** | **Pin** | **Signal** | **Definition** |
| 1 | 15EXTIN | 1 | 15VEXT | External instrument power. |
| 2 | CHGEXTIN | 2 | CHGEXT | External battery charger input. |
| 3 | GROUND | 3 | GROUND | |

# High Voltage Charger Board

These tables list the pin assignments for the connectors on the high voltage charger board. The connectors and the assemblies they connect to are listed in Table A-26. Tables A-27 through A-29 list connector pin assignments.

**Table A-29 High Voltage Charger Board Connections**

| High Voltage Charger Board | Via Cable Assembly | Connects To | Reference |
|---|---|---|---|
| J1 | M2475-62619 | DC supply, J2B | Table A-24 |
| J2 | M2475-62610 | Control board, J9 | Table A-10 |
| J3 | M2475-62616 | Safety relay | Table A-27 |
| J4 | M2475-62603 | Battery connector assembly | Table A-28 |
| J5 | M2475-83803 | Patient relay | Table A-27 |
| J6 | M2475-62616 | Safety relay | Table A-27 |
| J8 | M2475-83803 | Patient relay | Table A-27 |
| J9 | M2475-62616 | Safety relay | Table A-27 |
| J13 | M2475-83802, 83801 | Defibrillator capacitor and patient inductor | Table A-27 |
| J16 | M2475-83802, 83803 | Defibrillator capacitor and patient relay | Table A-27 |
| J37 | M2475-62620 | External power cable | Table A-29 |

**Table A-30 High Voltage Charger Board J3, J5, J6, J8, J9, J13, J16**

| Pin | Signal | Definition | Connects To |
|---|---|---|---|
| J3 | SR HV+ | Positive side of the safety relay. | Safety relay, HV+ (BLACK, M2475-62616) |
| J5-1 | VDC | AC/DC converter voltage. | Patient relay, PATRLY+ (M2475-83803) |
| J5-2 | AGROUND | | Patient relay, GROUND |
| J5-3 | RELAYRTN | Relay Return. | Patient relay, PATRLY- |
| J6 | HV CAP- | | Safety relay, HV– (WHITE, M2475-62616) |

**Table A-30** **High Voltage Charger Board J3, J5, J6, J8, J9, J13, J16 (Continued)**

| Pin | Signal | Definition | Connects To |
|---|---|---|---|
| J8 | NRMCL-2 | Patient relay, normally closed 2. | Patient relay, NRMCL-2 (NC2) (BLACK, M2475-83803) |
| J9-1 | +12R | Positive side of the safety relay drive coil. | Safety relay, COIL+ (M2475-62616) |
| J9-2 | SFRLYDR | Negative side of the safety relay drive coil. | Safety relay, COIL– (M2475-62616) |
| J13-1 | HV CAP+ | Positive terminal of the defibrillator capacitor; flying lead terminated by a 0.187 female faston. | Defibrillator capacitor, HV CAP+ (RED, M2475-83802) |
| J13-2 | HV CAP+ | | Patient inductor, INDUC-IN (RED, M2475-83801) |
| J16-1 | HV CAP- | Negative lead of defibrillator capacitor; flying lead terminated by a 0.187 female faston. | Defibrillator capacitor, HV CAP– (WHITE, M2475-83802) |
| J16-2 | HV CAP- | | Patient relay, HV CAP– (COM2) (WHITE, M2475-83803) |

**Table A-31** **High Voltage Charger Board J4 to Battery Connector**

| **High Voltage Charger Board** | | **Battery Connector** | | |
|---|---|---|---|---|
| **Pin** | **Signal** | **Pin** | **Signal** | Definition |
| 1 | VBAT2 | 2 | VBAT2 | Full current battery contact. |
| 2 | ESDGND | 6 | BATGND | Return path for battery voltage. Connected to the system ESD shunt path. |
| 3 | BATSER | 5 | BATSER | Serial communication port to the battery. |
| 4 | VBAT2 | 2 | VBAT2 | |
| 5 | ESDGND | 6 | BATGND | |
| 6 | BATTEMP | 3 | BATTEMP | Connection to the battery temperature sensor. |
| 7 | VBAT1 | 1 | VBAT1 | First battery contact made. The circuit is filtered to prevent sparks. |
| 8 | ESDGND | 6 | BATGND | |
| 9 | BATID | 4 | BATID | Connection to the battery ID resistor. |

**Table A-32 High Voltage Charger Board J37 to External Power Connector**

| High Voltage Board | | Power Connector | | |
|---|---|---|---|---|
| **Pin** | **Signal** | **Pin** | **Signal** | Definition |
| 1 | BATID | 4 | BATID | Connection to the battery ID resistor. |
| 2 | ESDGND | | No connection | |
| 3 | BATTEMP | 5 | BATTEMP | Connection to the battery temperature sensor. |

## Patient Inductor

These tables list the pin assignments for the connectors on the patient inductor. The connections are listed in Table A-30.

**Table A-33 Patient Inductor**

| Patient Inductor | Definition | Connects To | Reference |
|---|---|---|---|
| PEAK +5V | Supply for Ipeak transformer measurement. | Control board, J10-1, IPEAK5V | Table A-11 |
| PEAK | Ipeak transformer output (used by Ipeak measurement circuitry). | Control board, J10-2, IPEAK | Table A-11 |
| INDUC-IN (RED) | Input side (defibrillator capacitor) of waveshaping inductor. | High voltage charger board, J13-2, HV-CAP+ | Table A-27 |
| INDUC-OUT (RED) | Output side (patient) of waveshaping inductor. | Patient relay, INDUC– (NO1) (RED) | |

# CRT Deflection Board

On the CRT deflection board, J1 connects to J11 on the control board as listed in the table below. The pin assignments are the same on both connectors. See Table A-12 for pin assignments.

**Table A-34** **CRT Deflection Board Connections**

| CRT Deflection Board Connector | Connects To | Reference |
|---|---|---|
| J1 | Control board, J11 | Table A-12 |
| J2 | CRT Deflection yoke | Table A-32 |
| J3 | CRT Deflection break-away board | Table A-33 |
| J4 | CRT Deflection break-away board | Table A-34 |

**NOTE**

Each pin on the CRT deflection break-away board J5 connects to a pin with the same number on the CRT tube socket.

**Table A-35** **CRT Deflection Board J2 to CRT Deflection Yoke**

| Pin | Signal | Definition |
|---|---|---|
| 1 | VCOILOUT (YELLOW) | Vertical deflection coil drive. |
| 2 | VCOILRET (GREEN) | Vertical deflection coil return. |
| 3 | GND (BLACK) | Tied to DAG ground of CRT, through single screw attaching ground wire to CRT ears. |
| 4 | HCOILRET (RED) | Horizontal deflection coil return. |
| 5 | HCOILOUT (BLUE) | Horizontal deflection coil drive. |

**NOTE**

Each pin on the CRT deflection board J2 connects to a pin with the same number on the CRT deflection yoke.

**Table A-36** **CRT Deflection Board J3 to CRT Break-Away Board J3**

| CRT Deflection Board J3 | | |
|---|---|---|
| **Pin** | **Signal** | **Definition** |
| 1 | GND | Ground. |
| 2 | VIDEOOUT | Video control voltage: +28V = dot off, +4.3V = half bright, 0.0V full bright. |
| 3 | GND | Ground. |
| 4 | +12V | 12 volt supply. |

**NOTE** Pin numbers are the same on the CRT break-away board.

**Table A-37** **CRT Deflection Board J4 to CRT Deflection Break-Away Board J4**

| CRT Deflection Board J4 | | |
|---|---|---|
| **Pin** | **Signal** | **Definition** |
| 1 | INTENS | Display intensity (adjustable: -3.9V to 0.0V). |
| 2 | GRID-2 | CRT Grid bias voltage (adjustable: 0V to +200 V). |
| 3 | FOCUS | Focuses CRT beam |

**NOTE** Pin numbers are the same on the CRT break-away board.

# $SpO_2$ Board

On the $SpO_2$ board, P1 connects to J12 and P2 connects to J15 on the control board as shown in the table below. The pin assignments are the same on both connectors (see Tables A-13 and A-14 for pin assignments). Table A-35 lists connections on the $SpO_2$ board.

**Table A-38 $SpO_2$ Board Connections**

| $SpO_2$ Board | Via Cable Assembly | Connects To | Reference |
|---|---|---|---|
| P1 | M1722-60102 | Control board, J12 | Table A-13 |
| P101 | M2475-61621 | $SpO_2$ interface cable | Table A-36 |
| P2 | M2475-62622 | Control board, J15 | Table A-14 |

**Table A-39 $SpO_2$ Board P101 to $SpO_2$ Input Connector**

| $SpO_2$ Board P101 | | $SpO_2$ Input Connector | | |
|---|---|---|---|---|
| **Pin** | **Signal** | **Pin** | **Signal** | **Definition** |
| 1 | SIGNAL | 1 | SIGNAL | Received optical current. |
| 2 | FGND | A | FGND | $SpO_2$ isolated ground. |
| 3 | REXT1 | 3 | REXT1 | Cable coding resistor #1. |
| 4 | REXT2 | 5 | REXT2 | Cable coding resistor #2. |
| 5 | LEDSENCE | 6 | LEDSENSE | Detected current through LEDs. |
| 6 | LEDDR | 7 | LEDDR | Drive current for LEDs. |
| 7 | FGND | 2 | FGND | $SpO_2$ isolated ground. |

# M2478A DC Power Module

**Table A-40** **Power In Cable**

| MTA Pin | Signal |
|---|---|
| 1 | c15VXTIN |
| 2 | cCHGEXTIN |
| 3 | GROUND |
| 4 | cBATID |
| 5 | cBATTEMP |

**Table A-41** **Power Cable to Defibrillator**

| MTA Pin | Signal |
|---|---|
| 1 | c15VXTIN |
| 2 | cCHGEXTIN |
| 3 | GROUND |
| 4 | cBATID |
| 5 | cBATTEMP |

# Battery Connector Assembly

The battery connector assembly connects to J4 on the high voltage charger board. See Table A-28 for pin assignments.

# Defibrillator Capacitor

The defibrillator capacitor connects to J13 and J16 on the high voltage charger board. See Table A-27 for pin assignments.

## Patient Relay

Table A-35 lists the connection points for the patient relay.

**Table A-42 Patient Relay**

| Patient Relay | Connects To | Reference |
|---|---|---|
| NRMCL-2 (NC2) | High voltage charger board, J8 | Table A-27 |
| INDUC– (NO1) | Patient inductor, INDUC-OUT | Table A-30 |
| HV CAP– (COM2) | High voltage charger board, J16-2 | Table A-27 |
| PATRLY+ | High voltage charger board, J5-1 | Table A-27 |
| GROUND | High voltage charger board, J5-2 | Table A-27 |
| PATRLY- | High voltage charger board, J5-3 | Table A-27 |
| PACER+ (NC1) | ECG front end/pacer board, J51, J61, J62 | Table A-21 |
| OUTPUT + (COM1) | ECG front end/pacer board, J61-1 | Table A-21 |
| OUTPUT - (NO2) | ECG front end/pacer board, J62 | Table A-21 |

## Test Load

The test load assembly connects to J63 on the ECG front end/pacer board. See Table A-21 for pin assignment. In addition, the TO STERNUM point on the assembly connects to the sternum paddle pocket; the TO APEX point on the assembly connects to the apex paddle pocket.

## ECG Input Connector

The ECG Input connector connects to J1 on the ECG front end/pacer board. See Tables A-18 through A-20 for pin assignments.

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